CIVIL ENGINEERING

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Photo Courtesy E. Freyssinet, Engineer

ALBERT LOUPPE BRIDGE OVER THE ELORN, NEAR BREST, FRANCE

Volume 2 — AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852 — Number 2

FEBRUARY 1932

Among Our Writers

FRANK P. MCKIBBEN has had more than twenty years of teaching experience—at the Massachusetts Institute of Technology, and as professor of civil engineering at Lehigh University and at Union College. Recently he has served as city engineer of Schenectady, N.Y., and as consulting engineer for the General Electric Company and for the City of Rochester, N.Y. His contributions to engineering literature have been notable.

JOHN GIRAND, after valuable experience in hydraulic engineering in Arizona, went to South America as Hydraulic Engineer with the Departamento de Riego, Republic of Chile, on a dam and irrigation program. Recently he has been studying under Dr. A. E. Douglass, Director of Steward Observatory, Tucson, Ariz.

H. L. THACKWELL for 13 years carried on hydraulic engineering work in the Western states, in Canada, and in Central and South America. During the past 10 years he has been practicing municipal engineering in Texas.

HARRISON P. EDDY early in his career was superintendent of the Worcester Sewage Treatment Plant and of the sewage department of Worcester, Mass. In 1907 the firm of Metcalf and Eddy was established, specializing in water supply and sewage disposal practice. He is the author of two authoritative books and has contributed numerous technical papers to Society publications. He has received both the Norman and the Hering medals.

F. H. FRANKLAND has specialized in bridge engineering since 1913. For four years he was Managing Engineer for Waddell and Son: and for eight, Structural Engineer with Dwight P. Robinson and Company. He has designed, and advised on, many large bridge projects, and has carried on research in wind stresses in structures, impact effects in bridges, and properties of structural steel.

E. FREYSSINET, the eminent French engineer, is at present Vice-Président de la Société des Entreprises Limousin in Paris. In 1916 he was awarded the Caméré Prize by the Académie des Sciences for his attainments in developing long-span reinforced concrete arches, of which the Plougastel Bridge is the outstanding example.

J. T. THOMPSON, after graduation from Johns Hopkins University in 1917, served as Captain in the 305th Engineers, A.E.F. Since 1919 he has been a member of the faculty of the School of Engineering of Johns Hopkins University, and for the past decade has served as Highway Research Specialist in the U.S. Bureau of Public Roads.

HERBERT J. GILKEY has taught theoretical and applied mechanics at the University of Illinois, and civil engineering at the University of Colorado. He was connected with the U.S. Bureau of Reclamation model tests at Boulder, Colo., and is a member of the Consulting Board on Concrete Problems for Hoover Dam.

ELMER O. BERGMAN, in addition to his regular teaching at the University of Colorado, has worked summers for the American Bridge Company, the Wyoming State Highway Department, and the Bureau of Standards. He has also taught extension courses in higher structures and in the theory of elasticity to engineers of the U.S. Bureau of Reclamation at Denver.

W. E. LAND went in 1924 to Cuba with the Electric Bond and Share Company on transmission line construction. He next became connected with the South Porto Rico Sugar Company, as Assistant Civil Engineer, later acting as principal assistant to the superintendent of construction.

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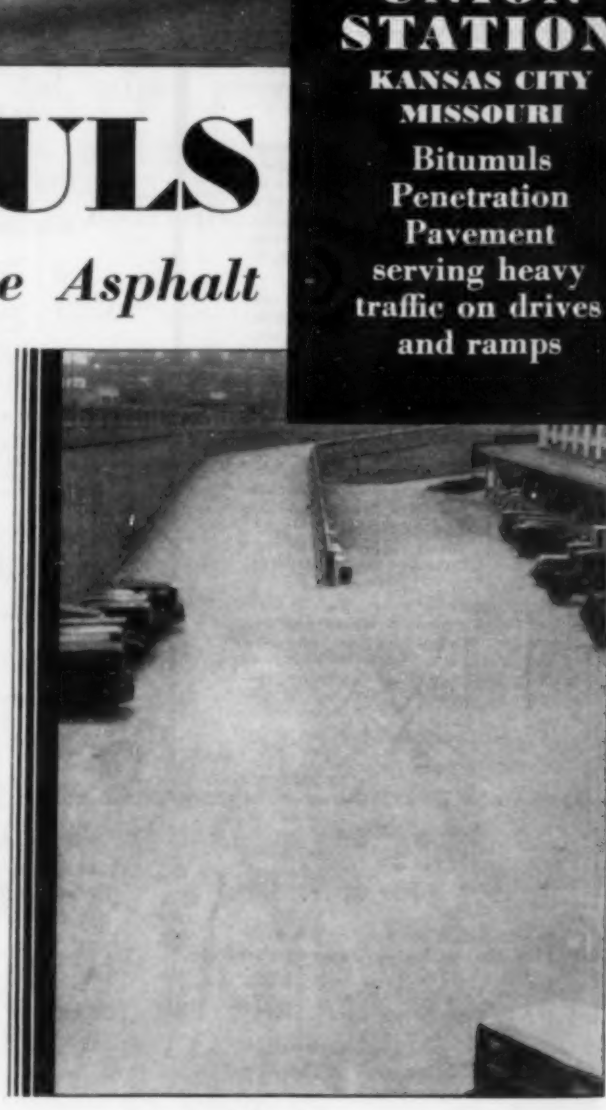

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Volume 2 — Number 2

Bridges and Poetry

A Plea for More Emphasis on Esthetics in Design

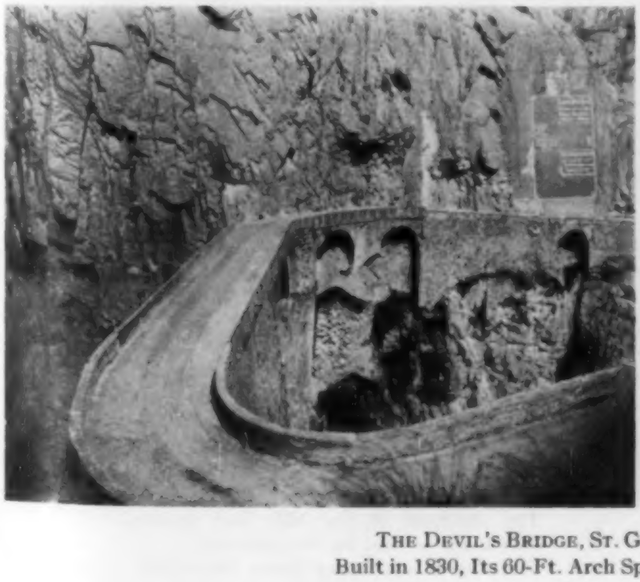
By Frank P. McKibben
Member American Society of Civil Engineers
Consulting Engineer, Black Gap, Pa.

IN THE erection of lasting monuments which are beautiful to the eye and uplifting to the spirit, designers and builders of bridges have opportunities no less important than the designers and builders of cathedrals. Many remarkable examples of beautiful bridges exist today to excite the admiration of artists and engineers alike. While concentrating on the proper design of cross sections of members and the details of placing reinforcing steel, engineers have tended to underestimate the importance of the esthetic treatment of external line and form. In making this plea for more poetry in bridges, Professor McKibben cites examples of bridges that have been the inspiration of poets.

TOO often the matter-of-fact mind, as typified by the engineer, is apt to be so occupied with thoughts of material things that it overlooks not only the beauty of literary forms but their value in daily pursuits as well. It is not, however, the general subject of literary appreciation that concerns us here, but rather the specific and limited interrelation of poetry and bridges, the reciprocal influence between the intangible beauties of poems and the tangible graces of bridges.

A bridge should be something more than a means of overcoming an obstacle. Besides utility it should possess beauty and permanence. It will express the character and individuality of the designer; and if he is of artistic temperament his creation will have a charm and loveliness that will appeal to the sense of beauty of all who view it—will even create such a sense where none exists. Not only will such bridges span chasms for the convenience of man but they will satisfy his longing for a better and more beautiful environment.

Bridge designers realize that bridges offer opportunities to build useful and beautiful monuments, comparable with, and in many cases excelling, those afforded by such architectural forms as buildings. Man has long desired to create beautiful houses of worship, governmental buildings of pleasing proportions, and lastly, office structures of monumental type. Sometimes this desire for architectural beauty has been satisfied. Often the attempt has ended in dismal failure. While the designer may fully realize that beauty as well as utility is the ideal, his ability may be insufficient to satisfy both criteria. But, other things being equal, the more poetry he has in his soul and the more artistic his temperament, the finer should be his architectural designs. If all this



The Devil's Bridge, St. Gothard Road, Switzerland
Built in 1830, Its 60-Ft. Arch Spans the River Reuss, 100 Ft. Below

is true, engineers and architects should cultivate these qualities. May it not be said properly that a beautiful bridge is poetry made tangible? The more the designer knows about bridges in poetry, the more poetry will be displayed in his bridges.

ROBERT BURNS FEATURES TWO BRIDGES IN DIALOGUE

Some of the greatest English poets have been inspired by bridges, and many poems exist expressing some

THE "AULD BRIG O' DOON," OVER THE AYR RIVER
At Ayr, Scotland

thought about such structures. While no claims are made as to its comprehensiveness, the accompanying reference list may serve to indicate the wide appeal that this theme has made to poets of two nations and of varying claims to fame. The examples which follow have been chosen rather on the basis of general interest than on that of pure literary merit.

In the autumn of 1786 a new bridge was begun at Ayr to replace the old one nearby. One of Burns' poems presents the old and the new stone bridges in a dialogue. As he walked at night, when "The drowsy Dungeon clock had numbered two," he heard the old and new bridges, represented as sprites, engaged in heated discourse, each belittling the other and discussing its imperfections. He recorded the conversation between them in his unique poem, "The Brigs of Ayr," finding much the same misunderstanding or lack of sympathy between young and old people that exists today, always has existed, and perhaps always will exist.

THE BRIGS OF AYR

By Robert Burns

Auld Brig

I doubt na frien', ye'll think ye're nae sheep-shank
Ance ye were streekit owre frae bank to bank!
But gin ye be a brig as auld as me—
Though, faith, that date I doubt ye'll never see—
There'll be, if that date come, I'll wad a boddle,
Some fewer whigmaleeries in your noddle.

New Brig

Auld Vandal, ye but show your little mense,
Just much about it, wi' your scanty sense;
Will your poor narrow footpath of a street—
Where twa wheelbarrows tremble when they meet—
Your ruin'd, formless bulk o'stane and lime,
Compare wi' bonny brigs o' modern time!
There's men o'taste would take the Ducat Stream,
Though they should cast the very sark and swim,
Ere they would grate their feelings wi' the view
O' sic an ugly Gothic hulk as you.

Auld Brig

Conceited gowk! Puff'd up wi' windy pride!
This mony a year I've stood the flood and tide;
And though wi' crazy eild I'm sair forfain,
I'll be a brig when ye're a shapeless cairn.

Longfellow's frequent mention of bridges reveals a real interest in, and admiration for, these structures. "The Old Bridge at Florence," a translation of "Il Ponte Vecchio de Firenze," is enticing because of the atmosphere of rich historical associations it conveys in so small a space. The line, "Florence adorns me with her jewelry," refers to the jewelry shops that have been carried by the bridge for several centuries.

THE OLD BRIDGE AT FLORENCE

Translation by Henry Wadsworth Longfellow

Taddeo Gaddi built me. I am old,
Five centuries old. I plant my foot of stone
Upon the Arno, as St. Michael's own
Was planted on the dragon. Fold by fold
Beneath me as it struggles, I behold
Its glistening scales. Twice hath it overthrown
My kindred and companions. Me alone
It moveth not, but is by me controlled.
I can remember when the Medici
Were driven from Florence; longer still ago
The final wars of Ghibelline and Guelf.
Florence adorns me with her jewelry;
And when I think that Michael Angelo
Hath leaned on me, I glory in myself.

Fortunate is the traveler who crosses afoot that remarkable highway, the Axenstrasse, from Brunnen to Fluelen and Altdorf along the eastern shore of the south arm of the Lake of Lucerne, thence over the St. Gothard to Ariolo in Italy. By no other means of travel will one see so well, and come in such close contact with, the grandeur of this route. Shortly after leaving Goschenen the traveler comes upon the Devil's Bridge with its span length of sixty feet, short as span lengths go, its height of one hundred feet above the swift Reuss, and its marvelous setting in a rocky gorge. In "The Devil's Bridge," Longfellow uses Prince Henry and Elsie and a guide as media for the narrative describing the structure.

The present stone bridge was built in 1830. The old span which stood nearby till 1888, when it was destroyed by flood, was the scene in 1799 of a defeat of the French by the combined Austrian and Russian troops under command of Suveroff.

THE DEVIL'S BRIDGE

(*From* Christus: A Mystery)

By Henry Wadsworth Longfellow

Prince Henry and Elsie, Crossing with Attendants

Guide

This bridge is called the Devil's Bridge.
With a single arch, from ridge to ridge,
It leaps across the terrible chasm
Yawning beneath us, black and deep
As if, in some convulsive spasm,
The summits of the hills had cracked,
And made a road for the cataract
That raves and rages down the steep!

PONT DU GARD, NÎMES, FRANCE
Part of a Roman Aqueduct Built in the First Century B.C.

PONTE VECCHIO IN FLORENCE
Goldsmith Shops Occupy This Famous Bridge

Lucifer, under the bridge

Ha! ha!

Guide

Never any bridge but this
Could stand across the wild abyss;
All the rest, of wood or stone,
By the Devil's hand were overthrown.
He toppled crags from the precipice,
And whatsoe'er was built by day
In the night was swept away;
None could stand but this alone.

Lucifer, under the bridge

Ha! ha!

Guide

I showed you in the valley a boulder
Marked with the imprint of his shoulder;
As he was bearing it up this way,
A peasant, passing, cried, "Herr Je!"
And the devil dropped it in his fright,
And vanished suddenly out of sight!

Lucifer, under the bridge

Ha! ha!

Guide

Abbot Giraldus of Einsiedel,
For pilgrims on their way to Rome,
Built this at last, with a single arch,
Under which, on its endless march,
Runs the river, white with foam,
Like a thread through the eye of a needle.
And the Devil promised to let it stand,
Under compact and condition
That the first living thing which crossed
Should be surrendered into his hand,
And be beyond redemption lost.

Lucifer, under the bridge

Ha! ha! perdition!

Guide

At length, the bridge being all completed,
The Abbot, standing at its head,
Threw across it a loaf of bread,
Which a hungry dog sprang after,
And the rocks reechoed with the peals of laughter
To see the Devil thus defeated!

Lucifer, under the bridge

Ha! ha! defeated!

For journeys and for crimes like this
I let the bridge stand o'er the abyss!

EUGENE FIELD'S MODERN PARODY ON MACAULAY'S HORATIUS

Macaulay's *Lays of Ancient Rome* include a poem commonly called "Horatius at the Bridge"—but perhaps more properly entitled "Ponte Sublicio"—a well known poem of devotion to country. Of course, this poem, founded on legend, describes not imperial Rome but the earlier settlement. When Chief Lars Porsena with the Etruscan armies approached the Tiber, intending to cross and sack Rome, the Consul decided to destroy the bridge to prevent the enemy's entrance. Horatius, captain of the gate, with two others volunteered to hold the foe at bay on the opposite side of the river till the bridge could be destroyed. While the battle raged furiously and the enemy was sufficiently delayed, Horatius' two companions withdrew across the tottering bridge just before it collapsed. Then Horatius, swimming the river, joined his countrymen and the city was saved.

From HORATIUS AT THE BRIDGE

(Lays of Ancient Rome)

By Thomas Babington Macaulay

Then out spake brave Horatius,
  The captain of the gate:
  "To every man upon this earth
  Death cometh soon or late,
And how can man die better
  Than facing fearful odds
For the ashes of his fathers
  And the temples of his gods."

* * *

"Hew down the bridge, Sir Consul,
  With all the speed ye may;
  I, with two more to help me,
  Will hold the foe in play.
In yon straight path a thousand
  May well be stopped by three:
Now who will stand on either hand,
  And keep the bridge with me?"
Then out spake Spurius Lartius,—
  A Ramnian proud was he:
"Lo, I will stand at thy right hand,
  And keep the bridge with thee."
And out spake strong Herminius,—
Of Titian blood was he:
"I will abide on thy left side,
  And keep the bridge with thee."

* * *

Back darted Spurius Lartius,—
  Herminius darted back;
And, as they passed, beneath their feet
  They felt the timbers crack.
But when they turned their faces,
  And on the farther shore
Saw brave Horatius stand alone,
  They would have crossed once more;

* * *

Alone stood brave Horatius,
  But constant still in mind,—
Thrice thirty thousand foes before,
  And the broad flood behind.
"Down with him!" cried false Sextus,
With a smile on his pale face;
"Now yield thee," cried Lars Porsena,
"Now yield thee to our grace."

* * *

They gave him of the corn-land,
  That was of public right,
As much as two strong oxen
  Could plough from morn till night;
And they made a molten image,
  And set it up on high,—
And there it stands unto this day
  To witness if I lie.

It stands in the Comitium,
  Plain for all folk to see,—
Horatius in his harness,
  Halting upon one knee;
And underneath is written,
  In letters all of gold,
How valiantly he kept the bridge
  In the brave days of old.

In his inimitable way Eugene Field has written a parody on Macaulay's poem. It presents a typical scene of bridge engineering in mid-Victorian times, when the revolving drawbridge was the prevailing type of movable bridge. These structures, of which a consider-

able number still exist, are being replaced by other types of movable spans. Their rotation to permit ships to pass through is accomplished either by power machinery or by long levers ("keys" in the poem) propelled by one or more men. The confusion resulting from interference with the street traffic is cleverly depicted by Eugene Field, who describes the conflict between navigation and vehicular traffic to which movable bridges are even now subjected.

How Flaherty Kept the Bridge

By Eugene Field

Out spake Horatius Flaherty,—a Fenian bold was he,—
"Lo, I will stand at thy right hand and turn the bridge with thee!
So ring the bell, O'Grady, and clear the railway track—
Muldoon will heed the summons well and keep the street-cars back."
Forthwith O'Grady rang the bell, and straightway from afar
There came a rush of humankind and over-loaded car.
"Back, back! a schooner cometh," the brave O'Grady cried;
"She cometh from Muskegon, packed down with horn and hide."
And "Back!" Muldoon demanded and Flaherty declaimed,
While many a man stopped short his course and muttered, "I'll be blamed!"
And many a horse-car jolted, and many a driver swore,
As the tother gangway of the bridge swung off from either shore.
And bold Horatius Flaherty a storm of curses heard,
But pushing bravely at his key, he answered not a word;
And round and round he turned the bridge to let the schooner through,
And round and round and round again O'Grady turned it too;
Till now at last the way is clear, and with a sullen toot
Twixt bridge and shore, ten rods or more, the tug and schooner shoot.
"Now swing her round the tother way," the brave O'Grady cried.
"Tis well!" Horatius Flaherty in thunder tones replied.
Muldoon waved high his club in air, his handkerchief waved high,
To see the stanch Muskegon ship go sailing calmly by;
And as the rafters of the bridge swung round to either shore,
Vast was the noise of men and boys and street-cars passing o'er.
And Flaherty quoth proudly, as he mopped his sweaty brow,
"Well done for you, and here's a chew, O'Grady, for you now."

POETIC EXPRESSION IN STONE

It seems possible that the Pons Sublicius at Rome, said to have been defended by Horatius, is the first bridge built over the Tiber, and the earliest bridge structure of which we have record. Several Roman bridges built between 100 B.C. and 100 A.D. are still standing and contain much of the original structures. The Pont du Gard, part of an aqueduct $25^1/_3$ miles long built by the Romans to carry water to the city of Nimes, France, over the valley of the Gard River, is in good condition at present, although it has been extensively repaired from time to time. It is believed to have been built by Agrippa, son-in-law of Augustus Caesar, during the first century B.C. This beautiful structure is as near poetry in a material form as stone can be.

When in 1176 Peter of Colechurch began the con-

Photo Courtesy T. D. Wood

Two-Span Stone Arch Bridge Over West Branch of Conococheague Creek, Pennsylvania

Built in 1850, Main Span 70 Ft.; Short Span 20 Ft. Note Similarity Between This Bridge and the "Auld Brig O' Doon"

struction of the first stone bridge across the Thames in London there existed even then a wooden bridge nearby. This first stone bridge had many arches of very narrow spans varying from 10 to 33 ft., and the piers were so thick that the width of the waterway was reduced to only 337 ft.—less than half that provided by the present London Bridge, begun in 1824 and completed in 1831. Along almost its entire length, the old London Bridge supported a series of timber houses, but as the bridge piers settled, the houses became unstable so that they finally had to be removed. The settlement was caused by undermining of the piers resulting from the narrowing of the waterway and a consequent increase in the velocity of the current. However, Peter's stone bridge remained standing from 1179 to 1832—a tribute to his ability. English-speaking children the world over sing the old ditty, "London Bridge Is Falling Down," which refers to the subsidence of the old piers, and the distortion and consequent removal of the houses on this structure, old when Columbus discovered America.

Reference List of Poems Relating to Bridges

Robert Burns: Tam O'Shanter

Will Allen Dromgoole: The Bridge Builder (See Civil Engineering for July 1931, page 907)

Ralph Waldo Emerson: The Concord Hymn

Oliver Wendell Holmes: A Roman Aqueduct

Thomas Hood: The Bridge of Sighs

Henry Wadsworth Longfellow: A Covered Bridge at Lucerne; The Bridge; The Bridge of Cloud; The River Rhone; Translations of *The Divine Comedy* of Dante (The Inferno, Canto XVIII and The Paradiso, Canto XVI)

James Russell Lowell: Mason and Slidell; A Yankee Idyll; The Vision of Sir Launfal

Edwin Markham: Anchored to the Infinite

Edna Dean Proctor: The Brooklyn Bridge

James Whitcomb Riley: From Delphi to Camden

Percy Bysshe Shelley: An Italian Ravine

Alfred Tennyson: Godiva; The Brook

John Greenleaf Whittier: The Bridal of Pennacook; the Wishing Bridge; The Countess; The Fountain; Among the Hills; The River Path

William Wordsworth: Steamboats, Viaducts, and Railways; An Evening Walk

Weather Records Projected Into the Future

Correlation Between Sun Spots, Rainfall, and Tree Rings Has Practical Value

By JOHN GIRAND

ASSISTANT HYDRAULIC ENGINEER, WITH JAMES B. GIRAND, CONSULTING ENGINEER
PHOENIX, ARIZ.

ALTHOUGH the oldest rainfall records in the United States extend back about a hundred years, engineers are often called upon to make hydraulic studies in territories where such records are less than ten years old. If, for example, large investments in works for irrigation or power must be based on the accuracy of rainfall and run-off predictions, it is important to understand how accurately to extend such meager data as may be available. That there is some definite relationship between rainfall, run-off, tree-ring growth, sun spots, and even clay varves seems indisputable. In this article Mr. Girand presents a method of procedure for determining cyclic variations in rainfall and run-off from tree rings and sun spots and in addition gives practical examples of the successful use of such data.

ONE of the oldest weather records available to mankind is to be found in tree rings. An examination of the stump of a tree will reveal a series of irregularly spaced, concentric rings, each representing one year's growth. The age of the tree may be easily determined by counting the rings from the outside, or from the last grown ring. These rings vary in thickness, and the pertinent fact is that the width of an individual ring accurately represents the climatic conditions during the time of its formation. A wide ring was grown in a period of abundant rainfall, and a narrow one in a period of scant rainfall.

Here then is a rainfall gage as old as the trees of a region—and trees cover a large part of the land area of the globe. In Arizona, where the studies here described were made, Dr. A. E. Douglass, Director of the Steward Observatory of the University of Arizona, Tucson, Ariz., has traced a tree-ring sequence back to 700 A.D.—an unbroken rainfall record of 1,200 years.

An application of these data was made on the watershed of the upper Salt River, Ariz., in connection with a proposed hydro-electric development. The drainage area above the project consists of 2,600 sq. miles of wooded, mountainous country which reaches an elevation of more than 10,000 ft. above sea level.

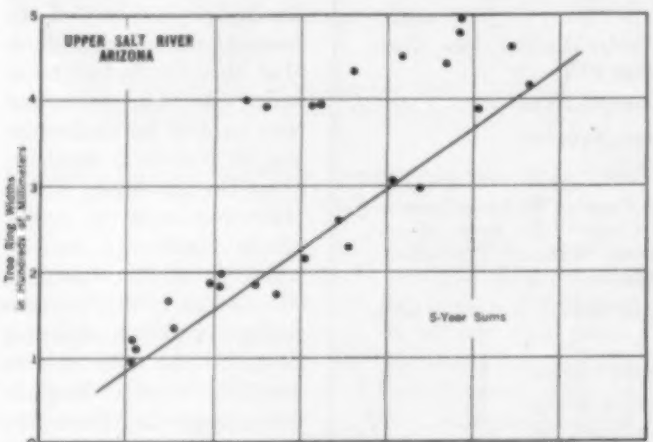


FIG. 1. RELATION BETWEEN TREE-RING GROWTH AND RUN-OFF
Points Are Five-Year Means

At the project site a river gaging station has been maintained for 7 years, and about 70 miles downstream, at the Roosevelt Dam, a station has been operated for 25 years. The readings of these gages agreed within reasonable limits, but it was felt that further data should be obtained. This was done by studying tree-ring growth by means of specimens from Cibecue, Ariz., a point centrally located on the watershed of the project. The accuracy of the records thus obtained may be seen from Table I. The rainfall record was taken at Fort Apache, also on the watershed, but 32 miles distant.

By examination of the specimens collected, a continuous tree-ring record was found, covering 269 years. In Fig. 1, this record is compared for a period of 30 years with the known run-off, as determined by the U.S. Geological Survey. The graph shows a very close agreement between tree-ring widths and run-off, except for periods of excessive growth. This lack of agreement for such periods might be explained on the assumption that the rainfall, though abundant, was so distributed throughout the year that only a small portion ran off. Excessive tree-ring growth for years having well distributed rainfall has been noted in particular cases.

The probability of occurrence of a given tree-ring width with a given run-off is shown in Fig. 2, from which it may be seen that in the short period of observed run-off, two separate years gave run-off greater than would normally be expected in such a short record. This fact points to the principal value of the tree-ring correlation.

TABLE I. COMPARISON OF RAINFALL AND TREE-RING RECORDS TAKEN ON THE SAME WATERSHED IN ARIZONA

YEAR	RAINFALL AT FORT APACHE	WIDTH OF TREE RINGS AT CIBECUE, IN MILLIMETERS	RATIO OF RAINFALL TO TREE-RING WIDTH
1906	21.67	0.71	30
1907	18.92	0.76	21
1908	13.90	0.91	15
1909	14.50	1.01	14
1910	12.21	0.76	16
1911	23.58	1.04	24
1912	17.35	0.65	26
1913	8.69	0.42	20
1914	9.63	1.03	10
1915	18.74	0.84	21
1916	26.46	0.96	27
1917	14 83	1.17	17

In many cases, where only short-term records are available, the engineer has no way of determining whether a given record embraces a wet, dry, or normal period. An examination of tree rings from the same

watershed will immediately indicate whether the period of record would be a fair basis for a run-off analysis.

When selecting the trees from which samples are to be taken, good judgment must be used. Since conifers seem to give the best results, trees of this species should be chosen if possible, and they should be so located that they are typical of the watershed. Those growing in a sheltered place, near a perpetual spring, or where ground-water is shallow, would not reflect average conditions.

Choose five or more trees and procure a sample from each. Perhaps the most convenient method of doing this is by means of an increment borer that extracts a core about the size of a pencil. Lacking this, a V-notch may be cut in the top of a stump on its diameter and the sample removed.

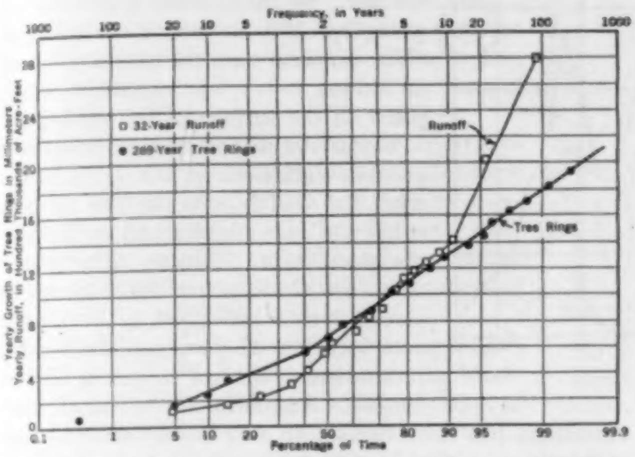


Fig. 2. Probability of Occurrence of a Given Tree-Ring Width for a Given Run-Off

If many rings are to be examined, a measuring device of some kind will be of assistance and will accelerate the work. The simplest and easiest to build consists of a low-powered microscope with cross hairs, which is fixed to a base plate. The carriage which holds the sample on the base plate is moved along until a tree ring coincides with a cross hair, when the position of the carriage is read on a scale. The carriage is then moved until a cross hair is on the next tree ring, when its position is read again. The difference between the two readings is the width of the tree ring. It will be convenient to have a slow-motion screw on the carriage movement, as well as a scale graduated in millimeters. If the tree rings are indistinct, the markings can be made clearer by rubbing the specimen with a rag moistened in kerosene.

The tree-ring widths thus obtained can be conveniently tabulated, and from such data a correlation can be made with the run-off for the years of record. When this correlation has been determined, the run-off record can be extended back as far as the tree rings have been observed.

Run-off for the upper Salt River, and five-year sums of tree-ring growth at Cibecue, which are plotted in Fig. 3, clearly show a cycle. Through the extrapolation of this cycle, it is possible to predict future run-off. The last year of tree-ring study was 1921, but the curve has been extrapolated to show run-off up to 1925. The extended curve gives the following values, as against the observed values of five-year sums:

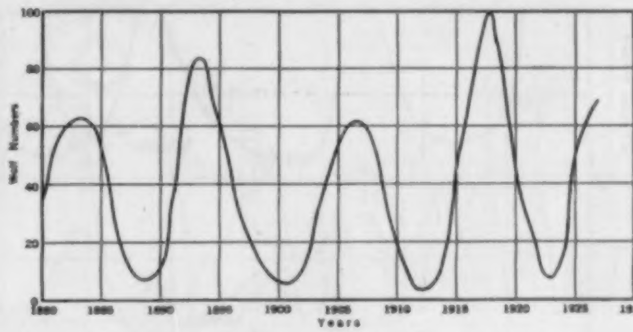


Fig. 4. Periodicity of Sun-Spot Cycles

Year	Predicted Run-Off Acre-Ft.	Observed Run-Off Acre-Ft.	Error Per Cent
1922	3,600,000	3,400,000	+ 6
1923	3,100,000	3,700,000	−16
1924	2,600,000	3,000,000	− 13
1925	2,300,000	2,300,000	0
Average........................			− 6

It is anticipated that within the next year, fresh tree-ring samples will be obtained to check this extrapolation.

An examination of the 1,200-year record previously referred to discloses periods of intense drought in the years near 700, 1000, 1300, 1600, and 1900. In all cases these extraordinary droughts extended over a period of five or six years. This 300-year period between droughts occurs with such regularity, and the droughts have such uniformity of intensity, that it seems logical to extrapolate these data to predict a similar drought in the year 2,200.

Residents of the district under observation in Arizona well remember the drought of 1900–1905. For example, Mormon Lake, the largest natural body of water in the state, was completely evaporated, for the only time in its existence, so far as is known.

The accuracy of conclusions is never greater than the premises upon which they are based. Exact water measurement has not as yet been perfected. Under laboratory conditions, current meters usually give results

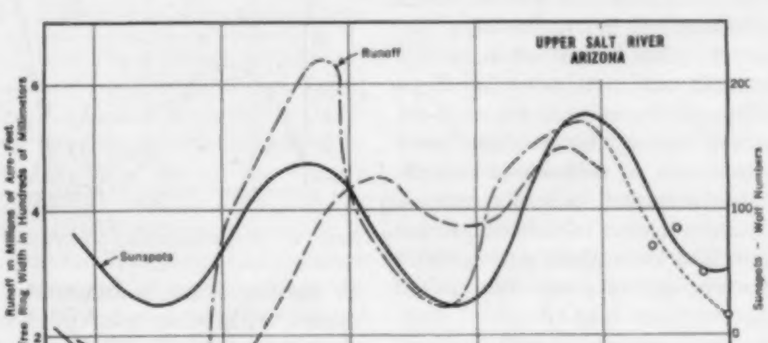


Fig. 3. Cyclic Variations in Run-Off, Tree-Rings, and Sun Spots On the Upper Salt River, Arizona; Points Are Five-Year Sums

accurate to within 1 or 2 per cent, and stream gaging of the highest order is usually correct to within 5 per cent; but in arid regions, with streams of "flashy" run-off, an average error of 10 per cent would seem to be a fair

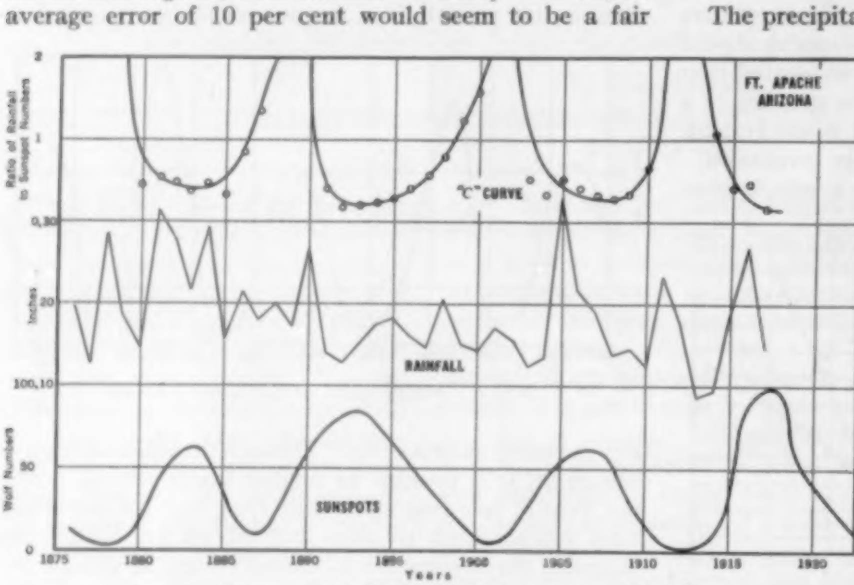


FIG. 5. CORRELATION BETWEEN RAINFALL AND SUN SPOTS

estimate. With a 30-year record accurate to 10 per cent, the value of a 269-year record is apparent.

That there is a direct relation between tree-ring growth and sun spots has been verified by Dr. Douglass. In an article in the *National Geographic Magazine*, Vol. 56, No. 6, he states:

> Evidence of the 11-year sun-spot cycle had been easily found in Arizona pine trees. The regularly recurring periods had been recorded for 500 years by tree rings, except for the interval from 1650 to 1725. During that 75 years the tree rings gave no evidence of periodical changes in the weather, such as were to be expected.
>
> Several years after we had encountered this puzzling fact, the late Dr. E. Walter Maunder, an eminent English astronomer, unaware of my findings, wrote to me that he had discovered that there were no sun spots between 1645 and 1715, and that if my tree rings did not indicate some effect of this absence of sun spots, my work was being conducted on an erroneous hypothesis.

This evidence is both authoritative and conclusive. The direct relation between tree rings and sun spots is also shown in Fig. 3. The fact that the correlation is not closer can be attributed to a number of variables which must be taken into consideration in determining the relation of rainfall to run-off. One is that when in arid zones the rainfall is less than one inch per rain, there may be no run-off. Although the rainfall for a given year may be above normal, it may be so distributed throughout the year as to result in subnormal run-off. Another variable, which ranks second in importance, is temperature. Other indeterminate variables, which make it impossible to correlate these data with greater exactitude, are solar radiation, and rate and direction of wind movement.

To the engineer who contemplates a study of the relation of sun spots and rainfall and who expects much difficulty, some encouragement is given by J. W. Shuman, M. Am. Soc. C.E., in the PROCEEDINGS of the Society, for May 1930, page 1086. In his discussion of the relation of sun spots and rainfall, he says:

> Stripped of all their involved mathematics, meteorological terms and backgound, the crux of these papers is, . . . a relationship does exist, which is easily discernible."

The precipitation cycle—precipitation, run-off, evaporation, precipitation, ad infinitum—is continuous and represents the expenditure of energy. As in the case of all energy-expending cycles, the energy must be supplied from an outside source. In this case, it is furnished by the sun. In his *Outlines of Astronomy*, paragraph 299, Sir John Herschel says: "The sun's rays are the ultimate source of almost every motion which takes place on the surface of the earth."

Variations in the motive power will produce variations in the cycle. Just what the variables in the sun are is a subject of astrophysics and need not be discussed here. Among other variations are those which have been observed in solar radiation, in the number and location of sun spots, in solar prominences, and in magnetic disturbances. Actual measurement of these variations has been carried on only in very recent times, with the exception of sun spots, which have been observed since as early as 807 A.D.

Some interrelation between all these variables seems to exist, although no mathematical expression for it has been evolved. Besides the assumption, unsubstantiated

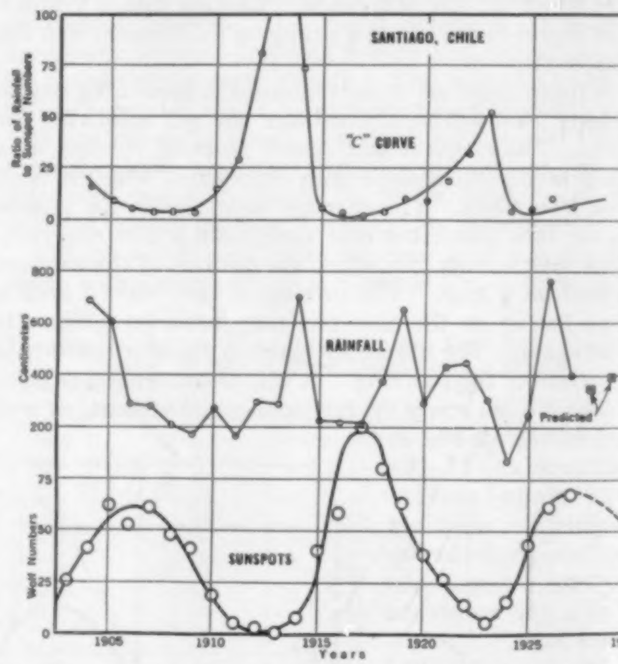


FIG. 6. CORRELATION BETWEEN RAINFALL AND SUN SPOTS

by mathematical computation, that sun spots are connected with other solar phenomena, the fact that only short-term records of the other variables are available forces the use of sun-spot numbers in attempting to solve the problem of solar influence on climate.

A preliminary examination of the record of sun-spot numbers shows a marked periodicity of occurrence, as indicated in Fig. 4. The cycle runs from maximum to

minimum and back to maximum in approximately 11 years. One practical application of these data has been made by Halbert P. Gillette, M. Am. Soc. C.E., who has shown that wet and dry periods synchronize with an 11-year sun-spot cycle. These findings substantiate his rainfall records based on tree rings by comparison with Baron de Geer's clay varves. Variations of thickness in these varves—or layers of silt deposited in pools and lakes formed by glacial damming—appear to show seasonal variations in run-off. Comparatively thick varves, deposited in the season of greatest run-off, alternate with thin ones, probably laid down in winter. Thus two varves correspond to one tree ring.

The conclusion of Mr. Gillette in regard to the effect of sun spots on rainfall has also been checked with observed rainfall at Los Angeles. That there is a direct relation between tree-ring growth, rainfall, run-off, and sun spots, seems indisputable. This being true, practical use should be made of the fact.

In studying the relation of sun spots to climatic conditions, there are two methods that may be used. The first is that of direct correlation, that is, by attempting to find a mathematical expression that will contain the necessary factors so that the problem can be put in the form of an equation. The second is a graphical solution, which consists essentially of "smoothing" the curves by various means in an attempt to find cyclic variations that may be extrapolated to give future expected rainfall.

The first of these two methods is apt to lead to involved equations. There are so many variables and unknowns to which arbitrary values must be assigned that the resulting equations are more nearly assumptions of the mathematician than they are solutions of the problem. However, for short-term predictions this method has been used with some success by meteorologists. In Fig. 5 is given a direct correlation between sun spots and rainfall at Fort Apache, Ariz.; and in Fig. 6, at Santiago, Chile. In each figure the C curve is a simple ratio of rainfall record and sun-spot numbers. Quite apparently these curves have some semblance of regularity—enough so that they may be extrapolated to give a prediction of expected weather.

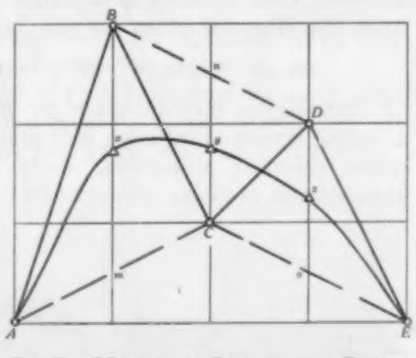


FIG. 7. METHOD OF SMOOTHING A CURVE

In 1852 Rudolf Wolf made the first careful assemblage and discussion of all the recorded observations on the number of sun spots. His tables give only the actual number of spots visible, without considering size or duration. Since that time, such numbers have been called Wolf numbers. Other tables are available which have weighted values, size and duration being included.

The graphical method is by far the best suited to the hydraulic engineer. Curve plotting, although laborious in some cases, is simple and can be trusted to assistants. "Smoothing" of curves can be done in many ways.

A simple and rapid curve-smoothing method giving a three-year weighted mean is here described (Fig. 7). Given the curve $ABCDE$.

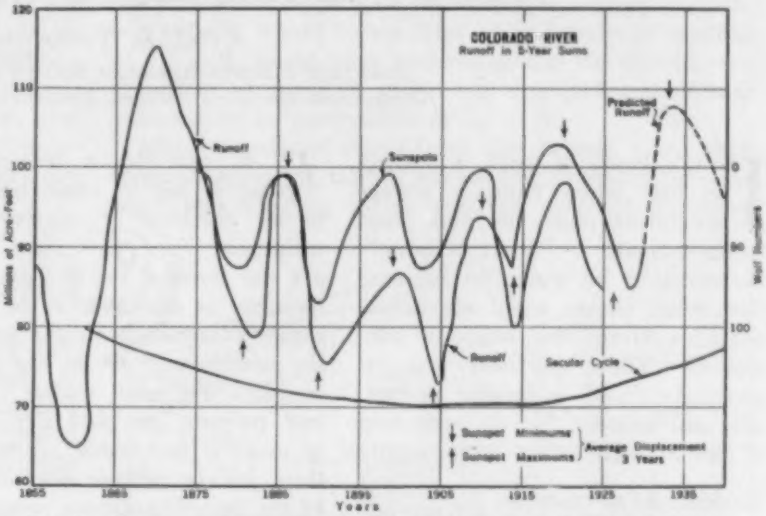


FIG. 8. COLORADO RIVER RUN-OFF COMPARED WITH SUN-SPOT CYCLES

Draw the line AC and drop a vertical from B to intersect AC at the point M. Bisect BM to find the point X. Draw the line BD. From C erect a vertical to intersect BD at N. Bisect CN to find the point Y. Continue this process for each succeeding set of three points. Draw a curve through A, X, Y, Z, etc. Then the point M represents the mean of the values plotted at A and C. Similarly, the point X is the mean for the points M and B.

$$M = \frac{A + C}{2} \text{ and } X = \frac{M + B}{2}, \text{ or } X = \frac{A + 2B + C}{4}$$

The lines may be sketched in by eye and the bisections made by estimation, as this method is fairly accurate for small distances. The resulting curve will show a high degree of accuracy.

In Fig. 3 is plotted the run-off of the upper Salt River, Arizona, together with the sun-spot cycle, the curves representing a series of five-year sums. The computation is perhaps more involved than necessary, as a three-year weighted mean should ordinarily give results sufficiently accurate for practical use. An application on a larger scale is shown in Fig. 8. Here the run-off of the Colorado River is shown in five-year sums, together with the maximum and minimum sun-spot numbers and the secular cycle form. It will be noted that in every case the periods of low flow were periods of maximum sun-spot activity, and that the periods of high flow coincided with minimum sun-spot activity.

Floods occurred in 1900, 1910, and 1919 while the sun-spot minimums came in 1902, 1913, and 1923, or 2, 3, and 4 years later than the high flows. For the whole curve, a mean value of 3 years gives a closer correlation. In effect, shifting the sun-spot curve is equivalent to introducing a factor of −3 in the dates of the sun-spot curves. In Fig. 8 the sun-spot curve has been inverted to emphasize the relationship.

These cycles are too well defined in this case and too well known by meteorologists to be regarded as "pure luck." As the next sun-spot minimum is to be expected in 1936, floods may be predicted for 1933. Since the secular cycle is ascending until 1948, greater run-offs are indicated for the year 1933 than any since about 1870. In this connection it may be well to note that, according to the present construction schedule for the Hoover Dam, work on the cofferdam is to be started in 1933.

Odor Nuisance Surveys

A Study of Sewage Plant Odors, Their Nature, Habits, and Control

By H. L. Thackwell

Associate Member American Society of Civil Engineers
Consulting and Constructing Engineer, Jacksonville, Tex.

It is rare that a sewage disposal plant is not at some time subject to the criticism of causing an odor nuisance. Too often these criticisms are not founded on fact and the real nuisance is discovered to be some unsanitary condition on the premises of the complainant or in the immediate vicinity. In odor studies, for whatever purpose, the first step should be to make a fact-finding survey so that there will be reliable data at hand as to the actual nuisance condition. In this article Mr. Thackwell presents the methods used at Jacksonville, Tex., to determine just how objectionable the odors from the city sewage disposal plant were, what territory they affected, and for what per cent of the time.

In the study of such a subject as the odors from a sewage treatment plant the first point to investigate is "What is odor?" It seems to be generally believed that what causes smell are actual particles from the odorous substances. These particles are exceedingly small, molecular in fact, and can account for the sensation of smell even when very highly diluted. As an example, $\frac{1}{460,000,000}$ of a milligram of mercaptan is an amount sufficient for a single whiff of the substance. It is estimated that there are 200,000,000,000 molecules in that single whiff of gaseous substance. It is these molecules, dissolved in the mucous covering of the olfactory organ, that bombard the olfactory hairs and thus initiate the nervous changes leading to the sensation of smell.

For the practical study of sewage odors there is no standard yardstick at hand. The intensity of odor depends on its volatility from dilute solution, its rate of diffusion, its absorption by a humid surface, and its solubility in liquids—all odorous substances are soluble in oil. The dispersibility of odors depends on the size of the gaseous cloud and on the velocity of the wind. Sewage contains excreta, household wastes, street washings, and by-products of industry, the combined liquor of which is a very complex mixture of chemical substances. Nuisances result from the putrefactive decomposition of organic matter. The foul smelling compound gases are hydrogen sulfide, mercaptines, and purines. Compounds of a pronounced odor must necessarily be volatile, and aeration allows them to escape. It is easier in practice to remove the odors from sewage than it is to remove the sewage odors from the atmosphere.

METHODS OF ODOR CONTROL

In the control of odors of sewage plants many artifices have been employed. Chemical control is often used, such as chlorine injection in raw or partially treated sewage, which reduces the hydrogen sulfide gases or replaces sewage odors by a chlorine odor. Gases may also be absorbed by passing them through activated charcoal, or by forming a solution in water or oil.

Gases may be drawn off and oxidized to carbon dioxide by burning in a flame and forcing up a stack. Odors may be partially controlled by covering all tanks, filters, and sludge beds, and conducting the mixed gases either to the higher atmosphere through a stack for dispersion, or by forced draft through a conduit to a point where their dilution in the natural atmosphere will not be likely to cause a nuisance.

In odor control studies, either of an old plant creating a nuisance, or for a plant under suspicion of creating objectionable odors, the first step is to make a fact-finding survey and odor maps. The object of such a survey is to locate all forms of possible nuisances, such as privies, livestock pens, sewer gas flues, septic tanks, and open drains receiving waste water in the neighborhood of the complaining area. Besides the nuisances, all houses connected to sewers and water supply wells, and other relevant features should be shown. These data should be plotted with a convenient scale on the study map of facts. Circles should be drawn at 500-ft. intervals from the disposal plant as a center, thus showing at a glance the air-line distance from the disposal plant to any house or object.

SMOKE SCREENS FOR TRACING ODORS

Odor studies may be made by observing the path of a smoke screen or smudge and plotting its course, with other relevant notations, such as time, humidity, atmospheric pressure, dispersibility and height of travel of the smoke flag, wind velocity, and other climatological data, including temperature. Odorous plant gases will tend to follow the general direction of a smoke cloud originating near the plant.

Sewage Disposal Plant, Jacksonville, Tex.

A map or sheet corresponding to the fact-finding map should be used for each day's observation, on

which is plotted the course of smoke flags or odors. Notes should also be taken and incorporated in the diary as to the location of all actually observed odors at various points throughout the zone of study. The study maps should be further divided by marking off 12 sectors of 30 deg. each, having their vertex at the center of mass of the sewage plant. Observations should include the statistical data of percentage of time that prevailing winds are observed in each sector, also the percentage of time that odors are noted in conjunction with prevailing winds and at various distances out from the center of origin of the odors.

It is advisable to use a color scheme for quick perception of plotted data, such as red for the smoke cloud, green for areas of observed odors, and black for critical points of observation.

The observer should check up on all rumors of nuisances and collect all records relative to the history of the plant and area in question. A single month's record, especially if taken during the hottest month of the year (July or August for Texas) will generally suffice to reveal the situation in its true light.

The map in Fig. 1 is a sample of the daily records made in the study of odors at Jacksonville, Tex., during August 1930, when there was some complaint as to odors from several residents living near the sewage plant.

During but one observation were plant odors noted over 1,000 ft. from the center of the plant, and that occurred when there was a good northeast wind blowing. On the other occasion when plant odors were noted in the direct line of the smoke flag, there was an almost imperceptible movement of air, not exceeding 3 miles per hour. At that time the smoke blanket fell within 500 ft. of the plant and spread over the ground in a broad thin cloud.

Regarding the movement of air currents from the plant, the following conclusions are drawn:

Trees about the plant aid in lifting floating gases into the upper, moving air currents. If the movement of these currents is slight, the gases will fall again when

A TYPICAL SMOKE FLAG FROM THE PLANT

cooled, and will be pushed along the ground or moved by diffusion. Wind velocities dilute the gases in about a constant ratio to the speed of travel. Beyond a certain concentration, the intensity of an odor is not in direct ratio to its dilution. Odors are not perceptible below a certain critical concentration.

As a rule, the movement of air currents is so related to the rate of formation of the gases at the plant, that objectionable odors must be strong to be perceptible farther than 1,500 ft. Dilution will then vary approximately as the square of the distance. From this observation it would follow that odors barely perceptible at 1,500 ft. would have to have double the intensity at the plant or point of origin—or double the molecular volume—to be perceptible at 2,110 ft.

Many reports of odors from the disposal plant were received when the telltale smoke flag indicated that the wind was blowing in an entirely different direction.

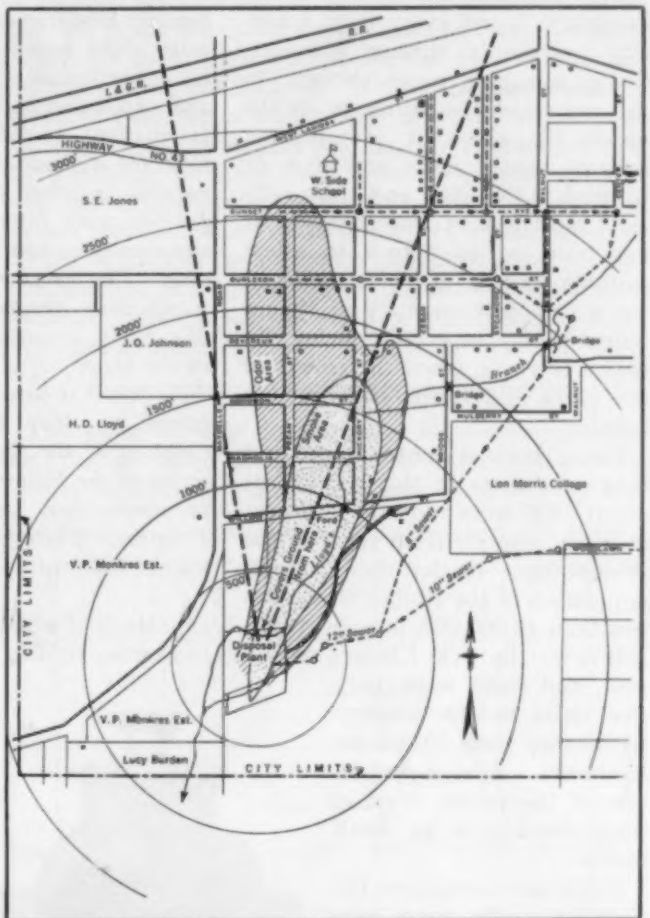


FIG. 1. VICINITY OF SEWAGE DISPOSAL PLANT, JACKSONVILLE, TEX. Odor Area 80 Per Cent Greater Than Low-Lying Smoke Area

Examination of the premises on which the odor was noted always disclosed some bad sanitary condition nearby, such as pig pens, chicken yards, privy vaults, and cesspools. There is a certain psychological objection to anything having to do with sewers that causes people to blame disposal plants for all objectionable odors.

No claim is made that any new scientific method has been developed for the study of odors, or for their control or regulation. However, an effort has been made to develop a practical outline for making fact-finding surveys and studies for local odor control. As a result of the survey at Jacksonville and the conditions surrounding the plant, the city inaugurated a clean-up campaign in the district. Since strict sanitary measures have been employed no further complaints have been made regarding an odor nuisance.

Water Purification—A Century of Progress

Engineering Study and Experimentation Have Revolutionized the Practice of American Municipalities

By Harrison P. Eddy
Member American Society of Civil Engineers
Consulting Engineer, Boston

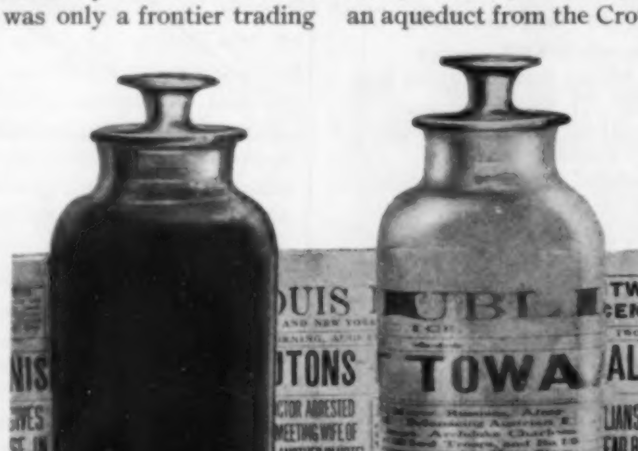
Development of American water supply practice during the last hundred years has been one of continuous advancement. Early sources of water were naturally good and needed little purification, but with the growth and expansion of cities, danger of contamination increased. At the same time the difficulties of finding suitable natural supplies multiplied. Municipalities were forced to treat available supplies since new ones were not procurable. The resulting changes in water purification practice, here described by Mr. Eddy, constitute a brilliant chapter in the history of American engineering. This paper is based on a radio talk presented on May 27, 1931, under the auspices of the Science Advisory Committee of the National Research Council, in cooperation with "A Century of Progress," Chicago's World's Fair Centennial Celebration, to be held in 1933.

ONE of the essentials of human life is pure water. Although everyone makes use of this necessary liquid every day, generally by simply turning a faucet, few people give much thought to the source of the water or to the means by which it is protected against disease germs and made fit to drink. For city and town officials in charge of water supply, it has been no easy task to select suitable sources of water and turn out a sufficient quantity of the required purity, especially during the past fifty years, when the growth of our cities and towns has been so rapid.

Going back a century, we find that conditions in this country at about 1830 were radically different in many respects from those of the present day. At that time the total population of the United States was less than 13,000,000, or approximately one-tenth of what it is now. In 1830 Chicago was only a frontier trading post, and there were only five cities in the country with more than 30,000 inhabitants. A large proportion of the people lived in rural districts or in small towns.

Under such conditions the need for public water supplies was not very great. Except in the larger cities and towns, most people obtained water from their own wells or from springs or streams near their homes. By 1830, however, 44 water works had been established in various parts of this country. Most of these drew their supply from wells, springs, or ponds. In the early years the water was probably of reasonably good quality, without the use of any artificial means of purifying it. In London, England, however, conditions were different. There had been many complaints that the drinking water was turbid, or muddy, and as early as 1829 a sand filter was built to clarify the water. This installation was followed by the establishment of similar filter plants at several places in Europe.

In 1830 the City of New York contained 242,000 inhabitants and was beginning to experience trouble in supplying them with satisfactory drinking water. The supply was obtained from many wells, both public and private, in various parts of the city. By 1832 the water thus obtained was so offensive that all who could afford to do so purchased water brought in hogsheads from unpolluted wells in the northern part of the island. A very bad outbreak of cholera during that year was followed by a more insistent popular demand for an adequate public water supply. It was not until ten years later, however, that water was brought into New York by an aqueduct from the Croton watershed, 40 miles distant.



Removal of Turbidity at St. Louis Water Purification Plant, 1915

Left, Mississippi River Water Before Purification. Right, as Drawn from the Tap After Purification

As the population of the United States increased and cities and towns experienced a rapid growth, the necessity for public water supplies became more evident. Plentiful supplies were needed for fire protection as well as for domestic purposes and for use in manufacturing processes. To obtain sufficient water, many municipalities were forced to draw their supplies from lakes, ponds, or rivers, or to form reservoirs by building dams across small streams. For a time these sources yielded water of satisfactory quality without any kind of artificial purification. However, the increase in population continued and in many places resulted in difficulties like those encountered in New York with the old well-water supply.

Judged by modern standards, many of the public water supplies were naturally of poor quality and others were seriously contaminated with sewage. The latter trouble

Municipal Water Filter at Lawrence, Mass.
Built in 1893

was due largely to concentration of population in cities and towns. With the introduction of public water supplies and the gradual increase in the number of houses provided with plumbing, the need for prompt and inoffensive removal of liquid wastes became acute. This led to the construction of sewers, which discharged into the nearest stream or other body of water. Frequently a public water supply was drawn from a body of water at a point where it was polluted by the municipal sewage. This situation created the danger of disease transmitted by means of the water supply.

As a result, in the latter part of the nineteenth century there were numerous cases of water-borne diseases in the cities of the United States. The most deadly of such ailments were cholera, dysentery, and typhoid fever. About 1880 it was common in American cities to have each year from 25 to 135 deaths from typhoid fever alone for each 100,000 of population. The organism which causes this disease, the typhoid bacillus, was discovered by Eberth and Koch in 1880 and since that time it has been the subject of research by hundreds of investigators working in many lands. In the campaign against this bacillus, which has resulted in a marked decrease in the prevalence of typhoid fever in the United States during the past 30 years, the purification of city water supplies has played an important part.

EARLY WATER FILTERS IN THE UNITED STATES

In America the first serious effort in the direction of filtering water was made by the City of St. Louis in 1866 when it sent James P. Kirkwood, second President of the Society, to Europe with instructions to study the art of removing sediment and turbidity from river waters. He made a report on this subject and presented a general plan for a purification works for St. Louis. Although this plan was not carried out, several filters were built by other cities as a result of his work. The first and the most successful of the early water purification plants in this country was built at Poughkeepsie, N.Y., in 1872.

The city of Lawrence, Mass., takes its water supply from the Merrimac River only eight miles below the Lowell sewers, and consequently typhoid fever formerly flourished in Lawrence. To remedy such situations, the Massachusetts State Board of Health in 1887 established an experiment station at Lawrence for the purpose of determining the best practicable methods of purifying water and sewage. One of the outstanding characteristics of the investigations at Lawrence was that they furnished data upon the engineering, chemical, and biological phases of the processes of nature artificially employed. Such thorough and unusually well coordinated data have had much to do with the development of sanitary engineering in the past forty years or more.

A few years before the experiments at Lawrence were begun, the germ theory of disease had been established through the work of Pasteur. During 1891 use was made of the new science of bacteriology in an investigation at the Lawrence Experiment Station, which demonstrated the ability of ordinary sand filters to remove typhoid fever germs from water. The immediate result of these studies was the construction in 1893 of a sand filter for the purification of the Lawrence municipal water supply. This was the first scientifically designed water filtration plant in America, and its success in reducing typhoid fever was notable.

FURTHER STUDIES IN WATER PURIFICATION

This early work of the Lawrence Experiment Station laid the scientific foundation for water purification. During the last five years of the nineteenth century and

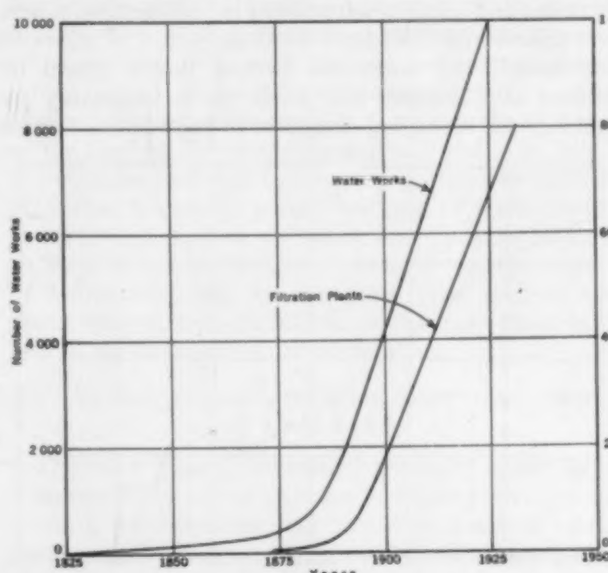


Fig. 1. Trend of Growth in Number of Water Works and Filtration Plants in the United States

the first two years of the twentieth, additional studies were made of processes of purifying river water at Louisville, Pittsburgh, Cincinnati, and New Orleans. Although these experiments were intended primarily to show the best practicable methods of water purification under local conditions, their value was soon widely recognized and similar tests have been made since in many places. In this way water purification has been brought to its present state of development.

The removal of disease germs from water by filters is accomplished by mechanical straining. But there is an-

other widely used means of accomplishing this aim. The application of chemical compounds to water for the purpose of killing germs has received considerable study at different times during the past sixty years. Investigations on the continuous application of small quantities of bleaching powder to the water supply of Jersey City in 1908, and the successful employment of this chemical in the same year in the highly polluted water of Bubbly Creek, at the purification plant in the stockyards of Chicago, established in this country the disinfecting value of bleaching powder. More recently, liquid chlorine has been adopted for use in disinfecting public water supplies.

A MODERN WATER PURIFICATION PLANT—GREENWICH (CONN.) WATER COMPANY
Above, the Filtration Plant. Inset, Interior of Filter Bay

Treatment of water with minute quantities of chemicals has been found by long experience to be harmless to consumers. Even though water drawn from the tap may have at times a somewhat objectionable taste of chlorine or its compounds, it is not on that account harmful to health. On the contrary, an extra dose of chlorine may occasionally be necessary to make doubly sure that all the disease germs in the water are killed.

In addition to germs of disease, natural waters may contain tiny plants and animals which cause objectionable tastes and odors when present in sufficient numbers. These micro-organisms have been the object of scientific study since 1889, when the Boston Water Board established at Chestnut Hill Reservoir a laboratory for examining the biological character of the various sources

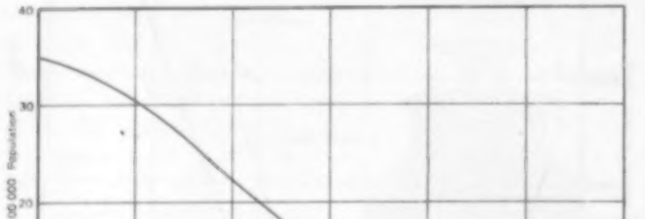


FIG. 2. TREND OF TYPHOID FEVER DEATH RATE IN THE REGISTRATION AREA OF THE UNITED STATES
Based on the Reports of the U.S. Census Bureau

of water supply. Due in large measure to work done there and at the Mount Prospect Laboratory in New York, effective methods have been developed for the control of taste-producing algae in water, largely by means of copper sulfate.

In comparatively recent years the general public has come to appreciate the value of water which is soft and palatable in addition to being of good appearance and free from disease germs. Hence there has been a steady increase in the number of supplies subjected to softening, to the removal of iron and manganese, and to aeration. The data in Fig. 1, taken largely from the 1925 *Manual of Water Works Practice*, American Water Works Association, shows steady growth in water treatment.

Another element contributing to the improvement of the quality of water supplies has been a more highly trained and specialized water-works personnel. The general acceptance of standard methods of water analysis and the promulgation by the U.S. Treasury Department of standards of water quality have also helped materially in improving water supplies.

During the past fifty years the increase in the number of public water supplies subjected to purification has been rapid. As long ago as 1924 there were 634 cities in the United States which had filter plants with capacities of one or more million gallons daily. A most significant indication of the popular demand for pure water was the 3 to 1 vote of the citizens of Chicago in the fall of 1930 in favor of the policy of filtration of the city's water supply, taken from Lake Michigan.

Largely as a result of improvement in the quality of drinking water furnished to city dwellers, there has been a steady decrease in typhoid fever in this country. This disease is now chiefly a rural problem. In fact, during 1930 there were only 1.6 deaths from typhoid for every 100,000 persons in 78 of the largest cities of the United States. Thus, notwithstanding the rapid growth and increasing congestion of our cities, their water supplies have been made safer than ever through the application of science. Although it is still highly desirable to obtain as pure a water before treatment as is financially practicable, it is now possible so to treat polluted waters that they will not endanger the public health. The decreasing death rate from typhoid fever in the whole United States is shown in Fig. 2. For the Century of Progress Exhibition, to be held at Chicago in 1933, interesting exhibits are being planned to show how the practical purification of our water supplies has depended upon discovery and development in the sciences.

Tunnels or Bridges—Which?

Economic Comparison of These Structures for Vehicular and Railroad Traffic

By F. H. Frankland

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Director of Engineering Service, American Institute of Steel Construction, New York

At a number of congested locations, the demands of traffic have required the crossing of a wide river either by bridge or tunnel. Between Detroit and Windsor, Canada, both a bridge and a tunnel now take care of the heavy traffic requirements. It has been the problem of engineers to determine the relative economic value of such structures in terms of cost of construction, operation, and maintenance. In this article Mr. Frankland presents the viewpoint of the bridge advocate, comparing existing and proposed tunnel and bridge crossings of the Hudson River and The Narrows, New York; of the Delaware River, at Philadelphia; the Detroit River, at Detroit; and the Mississippi River, at New Orleans. The data presented, based on cost per traffic lane, indicate that for comparable crossings tunnels are from $2^1/_3$ to 4 times more expensive than bridges.

PROBABLY a study of the relative economics of construction costs, maintenance, and operation for tunnels and bridges can be most effectively made by comparing the costs of specific bridges and tunnels in cases where both types of structures have been either constructed or investigated and proposed in the same locality. From a survey of bridge and tunnel projects in the United States, structures at five locations have been chosen as offering excellent data for such a comparative study, and these are listed in parallel columns at the bottom of the page.

In studying the relative economics of tunnels and bridges, the following factors must be considered:

1. Length—that is, similarity of conditions at the crossing, either on the basis of the same crossing or of crossings in which the governing conditions are truly comparable.

2. Traffic capacities—number of traffic lanes or lines available, and effect of interruptions to traffic due to such causes as vehicular breakdown, repair work on floors, and reconstruction of pavements.

3. Efficiency—effect of flexibility of routing, such as the provision of more lanes in the direction of maximum traffic, when needed.

4. Capitalization—true comparisons of relative maintenance and operation, whereby these charges are capitalized and included in the real cost of individual projects.

5. Unit prices, which must be considered for such items as labor, materials, and interest charges, so that comparisons are reduced to a common basis.

6. Deduction, from items 2, 3, and 4, of ratios of construction costs and maintenance and interest charges on a basis of capacity units.

From a study of the practicability of constructing bridges and tunnels for these crossings, adequate data with which to establish the true economic relationship between bridges and tunnels may be obtained, although in certain cases local conditions may favor either one or the other. Since the construction of a bridge connecting Brooklyn and the lower end of Manhattan is impracticable from many points of view, a tunnel is clearly indicated. Such a tunnel, now being considered by the Department of Plant and Structures of the City of New York, was briefly described on page 936 of the July 1931 issue of Civil Engineering.

The Manhattan end of the proposed structure would be located on West Street, near the Battery. This location gives access to the entire western waterfront of Manhattan with its piers and railroad terminals and, by means of ferries and the Holland Tunnel, makes readily accessible the section west of the Hudson River and its southern end. In Brooklyn the entrance and exit to the tunnel would be located on Hamilton Avenue to permit the flow of traffic from the factories and piers in the entire area from the Navy Yard to Bay Ridge in Brooklyn directly to the west side of Manhattan, and at the same time tend to relieve traffic congestion in Brooklyn, on the East River bridges, and in the cross streets of Manhattan.

TRAFFIC PEAKS IN OPPOSITE DIRECTIONS, LIKE TIDAL FLOWS

During traffic peaks, which generally occur between 7 and 9 o'clock in the morning and 4 and 6 o'clock in the evening for vehicular and suburban traction traffic in and about large cities, the greatest traffic movement for the morning peak is invariably opposite to that for the evening. A multi-lane bridge possesses the flexibility of traffic capacity afforded by using, if necessary, a majority of lanes in the direction of maximum traffic. In the case of a two-lane tunnel the interruption to traffic, when it becomes necessary to make extensive roadway repairs, is naturally much more serious than that caused by similar work on bridge roadways, where greater flexibility is possible in the arrangements for diverting traffic without serious interruptions.

The operating regulations for the Holland and Detroit tunnels are specific in regard to the spacing between vehicles, and this requirement is strictly enforced by squads of traffic policemen. In the case of bridges, it

Parallel Tunnels and Bridges at Five Localities in the United States

Crossing	Tunnel	Bridge
1. Hudson River, New York	Holland Tunnel (constructed) 38th Street (proposed)	George Washington (constructed) 57th Street (proposed)
2. Delaware River, Philadelphia	Philadelphia-Camden (proposed)	Philadelphia-Camden (constructed)
3. Mississippi River, New Orleans	New Orleans (proposed)	New Orleans (high level proposed)
4. Detroit River, Detroit	Detroit-Windsor (constructed)	Ambassador (constructed)
5. The Narrows, New York	Staten Island-Brooklyn (proposed)	Staten Island-Brooklyn (proposed)

is not necessary to specify such spacing, as the exhaust gases from motors are discharged into the open air, and the traffic capacity of bridges is considerably greater per lane with equal traffic control. Vehicular tunnels must be ventilated and lighted 24 hours each day, whereas bridges require no ventilation and less than half the lighting.

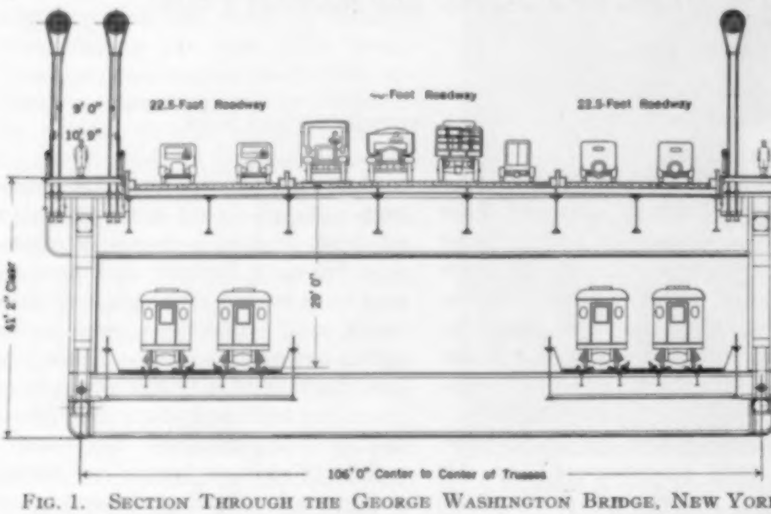


FIG. 1. SECTION THROUGH THE GEORGE WASHINGTON BRIDGE, NEW YORK
Four Rapid Transit Lines on the Lower Deck to Be Added When Needed

In the case of the crossing of the Hudson River at New York, undoubtedly the most important of all the cases under consideration, there are three tunnels and two bridges for comparison. Furthermore, the construction and actual operation of the Holland Tunnel and the completion, in October 1931, of the George Washington Bridge provide actual data based on experience. Physical conditions at specific crossings must necessarily be taken into account, as these affect the design or cost of construction.

Until 1913 the bridge commissions of New York and New Jersey had not considered the possibility of vehicular tunnels for the Hudson River crossing, as the work of these commissions, until that time, had been devoted to studies for bridges at 57th Street and between Fort Washington and Fort Lee. In the report of the commissions in 1913, however, the construction of a bridge at 57th Street and of twin tunnels at Canal Street was recommended. The cost of the bridge was estimated at $42,000,000 by Boller, Hodge, and Baird, and that of the tunnels at $11,000,000 by Jacobs and Davies. Both estimates were made in 1906.

The design for the bridge provided for 8 lines of rapid transit, 8 lanes of vehicular traffic, and 2 sidewalks. The estimate for the bridge was undoubtedly fair and conservative at the time of the presentation of the report, since costs were much the same in 1913 as they were in 1906. On the other hand, few real data were available for use in making the estimate for the tunnels and, in the light of after-knowledge, the $11,000,000 estimated was undoubtedly too low, even taking into account the low unit prices for labor and materials prevailing in 1906 and 1913.

OTHER TUNNEL ESTIMATES MADE

In 1917 the late George W. Goethals, M. Am. Soc. C.E., estimated the cost of twin tunnels for the Canal Street crossing at $12,000,000. The twin tubes proposed were divided by a middle floor into upper and lower roadways, the outside diameter of the tunnel being 42 ft. and the

AMBASSADOR BRIDGE BETWEEN DETROIT AND WINDSOR
A Toll Bridge with a Span of 1,850 Ft., Providing Five Traffic Lanes

inside diameter 36 ft. In 1922 a bid of $20,000,000 was received for this tunnel. In 1919 another estimate for a pair of tunnels was prepared for the tunnel commission, which was for $29,000,000. This estimate was revised in 1923 to $42,000,000, the increase being due principally to the addition of the cost of ventilation ($4,000,000) and the inclusion of other items.

The cost of the Holland Tunnel has been given as $48,400,000. This does not, however, include interest during construction, which is a legitimate part of the construction cost, and has been considered as such by the Port of New York Authority in estimating the costs of the George Washington Bridge and the proposed Mid-Town Hudson Tunnel at 38th Street. A description of the proposed Mid-Town Vehicular Tunnel connecting Brooklyn and Manhattan under the East River is given in an article on page 1172 of the October 1931 issue of Civil Engineering.

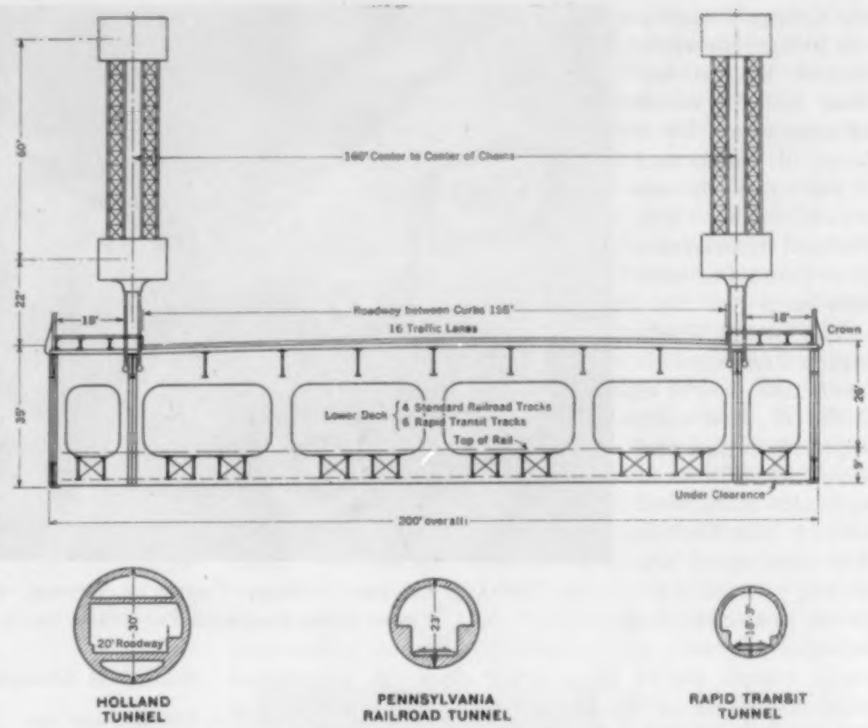


Fig. 2. Section Through the Proposed 57th Street Bridge, New York
Bridge Capacity Equal to Eight Holland Vehicular Tunnels, Four Pennsylvania Railroad Tunnels and Six Rapid Transit Tunnels; Bridge and Tunnel Sections Drawn to the Same Scale

For proper comparison the capitalized cost of operation and maintenance must also be taken into consideration. Estimating the interest during construction as low as $6,000,000 during the six and a half years of construction, and capitalizing $1,500,000, the annual charge for operation and maintenance, at 5 per cent, the total true cost of the Holland Tunnel is seen to be $84,400,000. The construction cost, plus interest during construction, but disregarding capitalization of the annual charges for operation and maintenance, amounted to $55,000,000.

A long-span bridge requires a certain minimum width for lateral stability. With a span of over 3,000 ft., as in

Traffic Conditions in the New York Plaza
Holland Vehicular Tunnel, New York

INTERIOR OF THE HOLLAND VEHICULAR TUNNEL, NEW YORK
Twin Tubes, Each with Two Traffic Lanes

the George Washington Bridge, the width should be not less than 120 ft., which affords room for 8 lanes of traffic and 2 sidewalks on one deck. The twin Holland tunnels have provision for only four lanes.

The George Washington Bridge, which has a total length of 8,300 ft., including approaches, and provision for 8 lanes of vehicular traffic, cost about $60,000,000. The capacity of the bridge and approaches can be enlarged to carry 4 rapid transit tracks on a lower deck—in accordance with provisions in the design—at an additional cost of $15,000,000 (Fig. 1).

The bridge proposed at 57th Street by Gustav Lindenthal, Hon. M. Am. Soc. C.E., will have a main span 3,600 ft. long with a total length of 10,000 ft., including approaches but not terminals, or about the same length as the Holland Tunnel. This structure is designed to accommodate 16 lanes of vehicular traffic and 10 tracks for railroads and rapid transit—altogether provision for 26 lanes of traffic, all of which are needed for this combined railroad and highway bridge. Necessarily the right-of-way and the main tower foundations for this structure are both very expensive.

Between terminals the total cost of the 57th Street Bridge has been estimated at $150,000,000, which includes $53,000,000 for real estate, interest and taxes during construction, and engineering expenses. To equal its proposed capacity would require 8 vehicular tunnels, such as the twin Holland tunnels; 4 railroad tunnels, like the Pennsylvania Railroad tunnels at 34th Street, and 6 rapid transit tunnels, equivalent to the same number of subway tunnels (Fig. 2). The cost of 8 vehicular tunnels between 14th Street and 57th Street—including, as for the bridge, real estate, interest and taxes during construction, and engineering—would be $3,000 per lin. ft. in each case for that part of the tunnels under the river, or 9,500 ft.; and $1,500 per lin. ft. for the 7,910 ft. of approach tunnels, or a total of $323,000,000. Four railroad tunnels having similar lengths under the river and in approaches, would cost $103,000,000. Six rapid transit tunnels, for lengths as described, would come to $105,000,000. Thus the total cost for tunnels having a capacity equivalent to that of the proposed 57th Street Bridge, would be $531,000,000 as compared to $150,000,000 for the bridge.

With the bridge approaches as planned, the wide boulevard on this bridge will not cause congestion of vehicular traffic in Manhattan. The 16 lanes on the bridge will distribute their traffic into Ninth, Tenth, Eleventh, and Twelfth avenues, and into three crosstown streets over separate ramps without grade crossings, having a combined capacity of 38 lanes—so that 60 per cent of the capacity of the streets will remain for local traffic, unaffected by the bridge.

The Port of New York Authority proposes to construct two vehicular tunnels under the Hudson River at 38th Street, to be known as the Mid-Town Hudson Tunnel. These will be very similar in cross section and capacity to the Holland tubes. The published estimate of cost covers the following items:

Construction and initial equipment required for operation	$57,800,000
Engineering, administration, and contingencies	8,700,000
Real estate	17,000,000
Interest during construction, and cost of financing	12,500,000
Total estimated cost	$96,000,000

In a preceding paragraph the cost of eight vehicular tunnels similar to the Holland tubes, but farther up the river, is given at $323,000,000, or $80,750,000 for two. This sum is more than $15,000,000 less than the $96,000,000 estimate announced for the Mid-Town Hudson Tunnel. Interest and operating costs will amount annually to over $7,000,000. It is proposed to build these twin tubes by the shield-driven method. The geologic formation through which the tunnel is to be built is practically identical with the conditions existing at the Pennsylvania Railroad and the Holland Tunnel.

DELAWARE RIVER CROSSING BETWEEN PHILADELPHIA AND CAMDEN

In 1917 the Delaware River Bridge and Tunnel Commission retained the firm of Waddell and Son, of which I was then managing engineer, to prepare a report and estimates of cost for a bridge and a tunnel crossing involving two tubes, one to accommodate two lines of vehicular traffic and the other two trolley lines. This report stated:

> It will be noticed that in none of these estimates of cost have we made any allowance for interest during construction . . . . In comparing the cost of the two tunnels with that for the bridge, account should be taken of the difference in cost of operation and maintenance, and this should be capitalized, and the capitalized amount should be added where it belongs. . . . Two and a half millions of dollars ($2,500,000) will have to be added to the various total costs of the two tunnels when comparing the said combined costs with that of the bridge.
>
> Again, the facilities for travel offered by the two tunnels should be compared with those provided by the bridge. A fair means of comparison is to find the ratio of the total clear usable widths of roadways of all kinds. In the two tunnels the said width

amounts to about 56 ft., while in the bridge it is about 96 ft., hence the accommodation offered by the two tunnels is only 58 per cent of that afforded by the bridge. This fact, in connection with the greater cost of the two tunnels and the danger of asphyxiation which always exists in an automobile tunnel in spite of all precautions that may be taken to avert the same, shows very clearly that the crossing of the Delaware River between the cities of Philadelphia and Camden should be above instead of below the water.

In this report were considered a 2-lane vehicular tunnel 7,961 ft. long and a 2-track electric railway tunnel 8,021 ft. long. Three methods of construction were studied and estimated as follows:

Case 1.	Trench method:	
	Vehicular tunnel	$6,974,000
	Railway tunnel	5,710,000
	Total	$12,684,000
Case 2.	Trench method, pumping river-bed material:	
	Vehicular tunnel	$7,131,000
	Railway tunnel	5,899,000
	Total	$13,030,000
Case 3.	Shield method (recommended)	$7,822,000
	Vehicular tunnel	6,400,000
	Total	$14,222,000

It was estimated that the capitalized value of the annual cost of ventilation, pumping, lighting, and operating would exceed the corresponding annual charges for the bridge by $10,500,000.

The study and estimate for the bridge considered called for 8 lanes, 4 to carry rapid transit tracks and 4 to accommodate vehicular traffic. The main span was 1,740 ft. and the two side spans each 345 ft., with spiral approaches at each end, and an underclearance above the river of 135 ft. The total estimated cost of the bridge was $11,000,000. The trench method for construction of the tunnels was considered impracticable; the shield method was preferred as being in accordance with the best developed practice in tunnel construction.

Compared to the estimated costs for the bridge and tunnels just described, the actual over-all cost of $37,000,000 for the Philadelphia-Camden bridge, completed in 1926, may appear inexplicable at first sight. The 1917 estimate for the bridge was based on the low unit prices of 1915 and no allowance was made for interest during construction. Also, the plans for the first bridge did not include the long and expensive approaches involving heavy land damages, which were a part of the bridge as actually built. The existing bridge provides for 6 lanes of vehicular traffic, two 10-ft. sidewalks, and 4 future rapid transit tracks—a total of 10 lanes as against 8 lanes contemplated in the 1917 design. Average annual maintenance and operating charges on this structure have been about $375,000.

PROPOSED CROSSING OF THE MISSISSIPPI RIVER

A board of advisory engineers, consisting of J. A. L. Waddell, J. Vipond Davies, and Bion J. Arnold, all Members M. Am. Soc. C.E., prepared in 1918 a comprehensive report for the Public Belt Railroad Commission of New Orleans covering the comparative economics of a combined highway and railroad bridge and two tunnels, the first to accommodate a double-track railroad and the second a vehicular tube with a roadway 16 ft. in width. This report went into very considerable detail, including the preparation of preliminary plans and estimates for several bridges and tunnel layouts, both high and low level. Both the bridge and the tunnels were estimated for three suitable crossing locations.

The Board of Engineers recommended the adoption of a low-level combined highway and railroad bridge, with a vertical-lift span to meet the navigation requirements of the War Department, at an estimated cost of $6,750,000. It was estimated that the railroad tunnel would cost $12,300,000 and the highway tunnel $5,700,000, a total of $18,000,000. Each tunnel was approximately the same length as the bridge, 13,200 ft. Owing to the low level of the ground on each side of the river, a high-level bridge would require very long approaches at each end, and the estimated cost for this type was $15,450,000. In connection with these estimates it is interesting to note a few of the unit costs used at that time. They were estimated on a 1915 basis because it was felt that the very high prices of 1918 were due to war conditions and that the earlier prices more nearly represented normal conditions.

PHILADELPHIA-CAMDEN BRIDGE OVER THE DELAWARE RIVER
Accommodates Six Lanes of Traffic on a 1,750-Ft. Span and Has Provision for Four Future Rapid Transit Tracks

Some of these unit prices were:

Cement	$1.15 per barrel
Yellow pine piling	10 cents per lin. ft.
Reinforcing bars	2 cents per lb.
Common brick	10.00 per thousand
Common labor	15 cents per hour

At the time of the preparation of the engineers' report, the War Department was ready to take under advisement the granting of a permit for a low-level bridge with a long-span vertical lift; consequently estimates were prepared for both high-level and low-level bridges. Due

to serious opposition to the low-level bridge project, plans have been made by Ralph Modjeski, M. Am. Soc. C.E., consulting engineer, for a high-level structure, estimated to cost $15,000,000, including interest during construction. Bids have been taken for the work, which is to be undertaken as soon as the financing can be arranged.

DETROIT AND WINDSOR CONNECTED

At Detroit both a highway bridge (1929) and a vehicular tunnel (1930) have been recently completed. The bridge provides a roadway width of 47 ft. with one 8-ft. sidewalk, thus accommodating 5 lanes of vehicular traffic. The tunnels provide for but 2 vehicular lanes. The cost of the bridge was about $22,000,000 and that of the tunnel about $25,000,000. The total length of the bridge is 8,180 ft., of which 4,540 ft. are in approaches and 3,640 ft. in the main bridge. The total length of the tunnel is 5,137 ft. between portals. In both cases the river crossing is approximately equal in length.

When the tunnel has been in operation for a full cycle of seasons it will then be possible to determine the public's preference for bridge or tunnel. The tunnel is located nearer the business center of Detroit and may therefore have some advantage in obtaining traffic. This advantage, however, will probably be offset to some extent by the street congestion at the tunnel approaches. It should be noted that location is an important factor in making a true comparison of the Detroit bridge and tunnel.

Studies and estimates have been made for a bridge and for a vehicular tunnel to cross The Narrows between Staten Island and Brooklyn, New York. Preliminary plans and estimates made by H. D. Robinson and D. B. Steinman, Members Am. Soc. C.E., show the cost of an 8-lane bridge, with a main span of 4,500 ft. and an underclearance of 235 ft., to be $60,000,000. The estimate of Charles E. Fowler for a bridge at this crossing, to accommodate 12 lanes of traffic with provision for future expansion to 18 lanes, was also for $60,000,000. The 4-lane tunnel recommended by the City of New York is estimated to cost $78,000,000. This last estimate was prepared some time ago, and it may be noted that, although the length of the proposed Narrows Tunnel is approximately the same as that for the 38th Street Tunnel, the geologic formation at The Narrows is considerably more unfavorable for the driving of tunnel shields than it is at 38th Street, and The Narrows location has double the depth of water. It is probable therefore that the cost of The Narrows Tunnel would be nearer $110,000,000 than the amount given in the estimate. In all cases the total length, including approaches, is about 10,100 ft.

For a tunnel the annual cost of operation would be at least $2,000,000 more than the comparatively small sum required for a bridge. The capitalized value of this difference in annual maintenance cost is $40,000,000. Accordingly, the equivalent first cost for the tunnel would be over $115,000,000, as compared with $60,000,000 for a bridge of at least double the capacity.

In April 1931, estimates were completed for a vehicular 2-lane tunnel and for a 4-lane high-level highway bridge across First Narrows at Vancouver, B.C. The estimate for the tunnel was $12,000,000, including installation and operation of ventilating equipment. It is calcuated that a bridge with a main span of 1,400 ft. can be built and connected with present traffic arteries on both shores for $5,000,000.

RECAPITULATION AND CONCLUSIONS

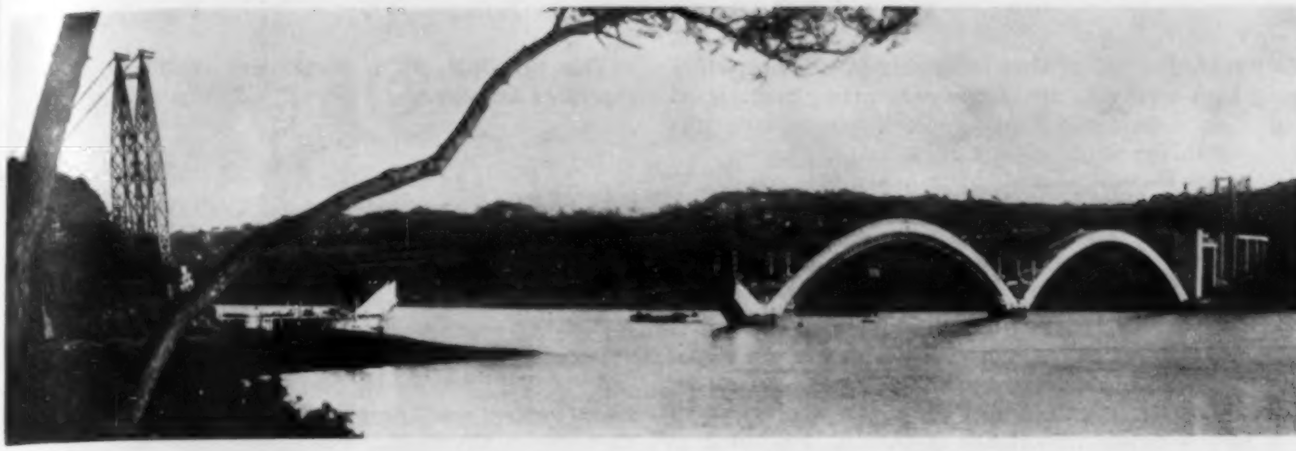
From data afforded by actual operating experience on the Holland and Detroit tunnels and many existing bridge structures, it is concluded that the annual charges for operation and maintenance of tunnels per traffic lane amount, approximately, to from 8 to 12 times those for bridges. In the comparable cases of the Holland Tunnel and the Philadelphia-Camden Bridge, a reflection of the cost of each is shown in the toll charges of 25 cents for the bridge and 50 cents for the tunnel. An inspection of the comparison of costs in Table I will show that with similar crossings the cost per traffic lane for tunnels is from $2^1/_3$ to 4 times that for bridges.

The author is indebted for information or comment to the following: Gustav Lindenthal, Hon. M. Am. Soc. C.E.; O. H. Ammann, M. Am. Soc. C.E., Chief Engineer, Port of New York Authority; Ole Singstad, M. Am. Soc. C.E., Chief Consulting Engineer on Tunnels, Port of New York Authority; Edward A. Byrne, M. Am. Soc. C.E., Chief Engineer, Department of Plant and Structures, City of New York; Ralph Modjeski, D. B. Steinman, J. Vipond Davies, and Shortridge Hardesty, Members Am. Soc. C.E.; and to Charles E. Fowler.

TABLE I. COMPARISON OF SIMILAR CROSSINGS FOR TOTAL COST AND COST PER LANE OF TRAFFIC

Crossing	Total Cost	Number of Lanes	Cost per Traffic Lane	Per Cent	*Percentages Adjusted to a 1930 Basis
Hudson River at New York:					
Holland Tunnel (completed)	$ 55,000,000	4	$13,750,000	237	232
38th Street Tunnel (estimated)	96,000,000	4	24,000,000	413	413
George Washington Bridge (completed)	60,000,000	8	7,500,000	130	127
George Washington Bridge (future addition)	75,000,000	12	6,250,000	108	106
57th Street Bridge (estimated)	150,000,000	26	5,800,000	100	100
Delaware River, Philadelphia to Camden:					
Tunnel (estimated)	14,200,000	4	3,550,000	258	306
Bridge (1917 estimate)	11,000,000	8	1,375,000	100	119
Bridge (completed)	26,000,000	10	2,600,000	188	100
Mississippi River at New Orleans:					
Tunnel (estimated)	18,000,000	4	4,500,000	400	400
Bridge—high level (estimated)	15,450,000	6	2,575,000	229	229
Bridge—low level (estimated)	6,750,000	6	1,125,000	100	100
Detroit River, Detroit to Windsor:					
Tunnel (completed)	25,000,000	2	12,500,000	277	277
Bridge (completed)	22,000,000	5	4,500,000	100	100
The Narrows, Staten Island to Brooklyn, New York:					
Tunnel (estimated)	78,000,000	4	19,500,000	260	260
Bridge (estimated)	60,000,000	8	7,500,000	100	100

* From construction cost indices prepared by *Engineering News-Record;* corrections applied as of date of estimates or of awarding contracts.



Albert Louppe (Plougastel) Bridge Near Brest, France, During Construction

Concrete Arches for Long-Span Construction

Remarkable Bridge Designs Claimed Practicable by a Noted French Engineer

By E. Freyssinet
Ancien Ingenieur des Ponts et Chaussees
Neuilly-Sur-Seine, France

Translated and Reviewed by J. T. Thompson, M. Am. Soc. C.E.
Professor of Civil Engineering, Johns Hopkins University, Baltimore

To American engineers the statement that it is possible to build reinforced concrete arches of 3,000 or even 5,000-ft. span, has a fantastic sound, particularly when it is remembered that the largest concrete span we have been able to build so far in this country is about 400 ft. long. However, the thesis that longer spans are practicable is advanced and defended by the famous French engineer, E. Freyssinet, who has recently completed the world's longest concrete arch, in the Albert Louppe (Plougastel) Bridge near Brest. This monumental structure, which carries a standard-gage railroad as well as a highway, consists of three arch spans each 612 ft. from center to center of supports. Its construction has been amply described in both French and American technical literature, but a number of theoretical considerations have not been generally touched upon.

In a recent paper, presented at the First International Congress for Concrete and Reinforced Concrete, Liege, in September 1930, M. Freyssinet discussed the theory and experience that led him to his present conception of the long-span concrete arch. I have translated this paper from the original French and reviewed it in the hope that it may stimulate thought along similar lines among members of the engineering profession in this country. J. T. Thompson

Although E. Freyssinet is the originator of the method of using hydraulic jacks to decenter concrete arches and adjust their stress conditions, he does not rely entirely upon this means for long-span construction. It is rather by novel uses of materials that he plans to achieve arches of unprecedented dimensions.

Much importance is attached to the reduction of specific weight, a term defined as the weight of a unit one meter long, having a cross section large enough to safely carry an axial load of one metric ton. Specific cost is defined as the cost of such a unit length.

In steel construction the specific weight and cost are well established and subject to but little modification. But such is not the case with reinforced concrete. The interplay of the three fundamental materials, cement, aggregate, and steel, offers a considerable number of possibilities, of which only a few have thus far been exploited.

Assuming first that, in general, the use of concrete in pure tension is to be avoided, the possibilities of reducing its specific weight and cost are largely dependent upon bettering its quality by selecting properly graded aggregates, by control of the water-cement ratio, and by the use of vibration in placing.

By exercising the proper care in these particulars it is possible to raise the strength of concrete to practically that of its aggregates considered in the mass, that is, from 3,000 to about 15,000 lb. per sq. in., and with certain aggregates, to 20,000 lb. per sq. in. It should be remembered that the French standard of concrete strength, to which these figures refer, is based upon 8-in. cubes 90 days old, and that the strength of cubes is approximately 1.25 times the strength of cylinders of the same diameter.

Since these methods do not add greatly to the cost but are largely a matter of organization, the specific cost as well as the specific weight can be reduced to approximately one-fifth the values commonly looked upon as satisfactory at the present time. It is pointed

out by M. Freyssinet that the methods which produce these high strengths are slowly penetrating practice, so that already in certain special precast units, strengths of 15,000 lb. per sq. in. are commonly obtained.

REINFORCEMENT MORE EFFICIENTLY PLACED

Engineers do not know very much about the use of hard steels in framed structures, M. Freyssinet feels. Even in cables for suspension bridges, safe working stresses are penalized because of brittleness. But it is believed that hooped compression members are never brittle, no matter what the natural brittleness of the elements comprising them may be.

A fact of prime importance is that it is possible to do away with brittleness in concrete members reinforced against lateral expansion. Experience proves that all brittle bodies become susceptible to large plastic deformations when subjected simultaneously to compression and to a sufficiently great restraint against lateral expansion. This is what is accomplished in members with hooped reinforcement.

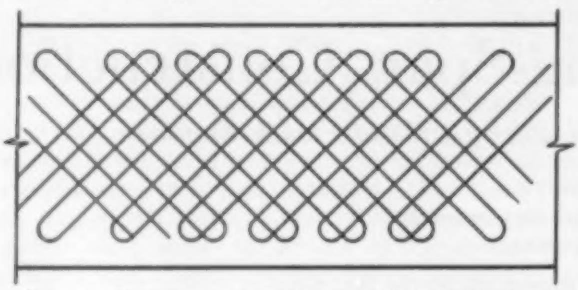


FIG. 1. FREYSSINET'S TRANSVERSE REINFORCEMENT FOR BULKY CROSS SECTIONS

It can be demonstrated that if a load is transmitted through a frictionless substance like water by applying the load to a tight-fitting piston in a tube filled with the substance, the maximum load, P, which can be thus transmitted depends on the bursting strength of the tube. This load is equal to one-half that, P', which the tube, acting as a short column, will carry by itself. If, however, the material in the tube possesses a high internal friction, the load transmitted by it can be greatly increased.

This principle, for a frictionless substance, may be expressed as follows:

$$P = \frac{P'}{2}$$

It has been demonstrated by Considère that, for a substance possessing a high internal friction, K, and a compressive strength, when unrestrained, C,

$$P - C = KP'$$

It has been established experimentally by M. Freyssinet that a close analogy exists between a closed tube and a hooped concrete member, for which he has evaluated the coefficient K. For large values of $P - C$, and for rough, hard aggregates, he finds that K equals 2, or a little more. His experiments have been verified in all their essentials by the French engineer Caquot.

Thus he has reached the conclusion that the most efficient system of reinforcement for bulky cross sections consists of a series of loops made of high-strength steel wires. These are arranged as shown in Fig. 1, so that the concrete is restrained against lateral expansion in every direction. This type of hooping will be referred to as "transverse reinforcement," since it lies in a plane normal to the direction of the compression.

SPECIFIC WEIGHT OF HOOPED COMPRESSION MEMBERS

From these observations it is deduced that the specific weight of concrete compression members with hooped reinforcement may be reduced to a value much below that for ordinary steel members. The weight of a steel member one foot long that will carry a load of one ton is about 0.34 lb., including rivets, connections, and stiffeners, for steel having an elastic limit of 35,000 lb. per sq. in. This same specific weight can be obtained in plain concrete having a strength of 7,000 lb. per sq. in. As has been pointed out, M. Freyssinet believes it possible to produce concrete of two or three times this strength.

If, however, the cross section is reinforced by hooping in the form of steel wires having a strength of something over 200,000 lb. per sq. in. and a volume equal to 10 per cent of the total volume, and if concrete having a

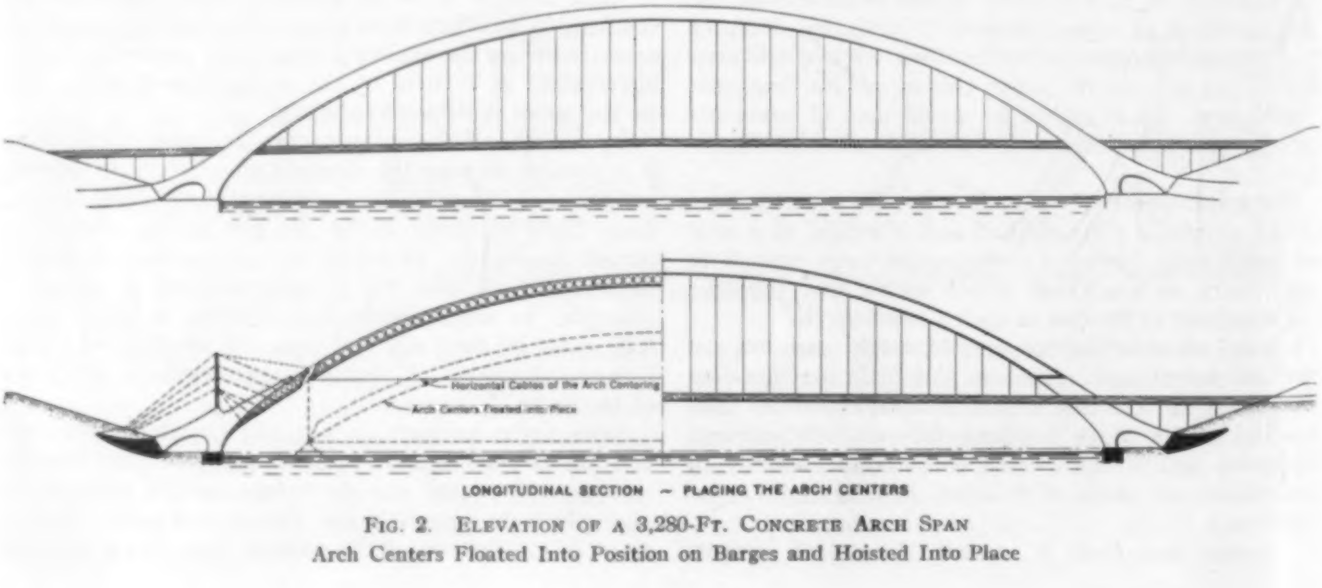


FIG. 2. ELEVATION OF A 3,280-FT. CONCRETE ARCH SPAN
Arch Centers Floated Into Position on Barges and Hoisted Into Place

SEQUENCE OF CONSTRUCTION WORK ON A 612-FT. ARCH RIB
A Hollow Rectangular Section 30 by 15 Ft. at the Crown

strength of 20,000 lb. per sq. in. is used, a member with an ultimate resistance of around 70,000 lb. per sq. in. will be obtained. Such a member would have a specific weight only one-third that of steel. It would correspond in this respect to a steel having an elastic limit of 350,000 lb. per sq. in.

The possibilities of low specific weight in concrete reinforced against lateral expansion greatly surpass those for any other system of construction using a single material. Because of the necessity of fabricating, members made from a single material are always much less reliable than homogeneous prisms of that material, hence the absolute necessity of using only those materials with elastic limits much lower than their ultimate strengths. However, concrete reinforced against lateral expansion produces members which are quite plastic even though composed of brittle materials. Therefore the elastic limit of such members may be considered to be in the neighborhood of their ultimate strength.

POSSIBILITIES OF CROSS SECTIONAL FORM

In regard to the actual forms of arches, M. Freyssinet believes it is possible, using present methods of making concrete and of eliminating "parasitical stresses" by hydraulic jack adjustment, to construct arches of solid rectangular section having a span of 1,000 ft. or more. However, since certain limiting ratios of longitudinal and transverse dimensions must be maintained, the sections increase to such proportions as to give rise to enormous dead-load thrusts on the abutments.

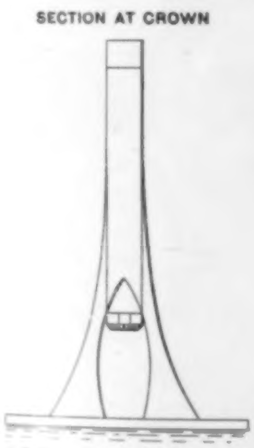


FIG. 3

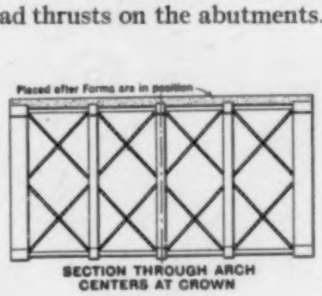


FIG. 4

CROSS SECTION OF ARCH AND OF CENTERING
Proposed Plan for a 3,280-Ft. Span

The advantages of hollowing the section are then obvious, for the added cost of form work is more than offset by savings in volume and in foundation costs.

One method which he has used successfully is to divide the rectangular cross section into a number of smaller rectangles formed by constructing intrados and extrados slabs connected by two or more vertical spandrel walls. This general plan was employed in the Albert Louppe (Plougastel) Bridge, where the rectangular section, roughly 30 ft. wide by 15 ft. deep at the crown, was divided into three rectangles, the central one being 15 by 15 ft., and those on each side of it, $7^1/_2$ by 15 ft.

HIGH-STRENGTH CONCRETE FOR LONG ARCHES

In order to show in condensed form the possibilities of long-span arches for this tubular type of construction, Table I is presented, giving a tabulation of stresses derived, by the laws of mechanical similitude, from the computed stresses of the Albert Louppe Bridge.

By reinforcing a 15,000-lb. per sq. in. concrete—which M. Freyssinet claims can be made without difficulty—with about 2.5 per cent of transverse steel having an elastic limit of 120,000 lb. per sq. in., a material can be produced which will meet the demands of a 5,000-ft. arch. M. Freyssinet estimated that its cost in France in 1930 would have been about 1,000 francs per cubic meter, equivalent to $30 per cubic yard at an exchange rate of 25 francs to the dollar. As early as 1912 he produced concrete in the massive hinge of a large arch which tested 15,000 lb. per sq. in. and actually carried 3,600 lb. per sq. in. in service.

He outlines the essential dimensions, quantities, and cost of a 3,280-ft. (1,000-m.) arch as follows:

ITEMS	AMOUNT
Rise	560 ft.
Depth at crown	52 ft.
Width at crown	66 ft.
Depth at support (approximate)	132 ft.
Width at support (approximate)	264 ft.
Section at crown	860 sq. ft.
Weight per foot at crown	130,000 lb.
Total volume	160,000 cu. yd.
Per cent transverse steel	2
Per cent longitudinal steel	0
Weight of steel	33,000 tons
Weight of decks per foot	24,000 lb.
Combined usable width of decks	165 ft.
Live load per foot	20,000 lb.
Maximum compression in concrete	4,000 lb. per sq. in.
Total thrust on supports	440,000,000 lb.
Probable cost of arch rib alone	$ 4,700,000 (120,000,000 francs)

In M. Freyssinet's opinion, the use of hinges is scarcely justified. Fixed arches are much to be preferred, but of course the fixing of very long arches, particularly if they are flared, entails a much more extensive foundation.

TABLE I. TOTAL STRESSES DERIVED FROM COMPUTED STRESSES IN THE ALBERT LOUPPE BRIDGE—IN POUNDS PER SQUARE INCH

Cause of Stress	Span in Feet		
	1,640	3,280	4,920
Dead load (arch ring)	1,210	2,420	3,640
Dead load (superstructure)	300	490	610
Live load and wind	610	970	1,210
Shrinkage, temperature, and dead-load rib shortening	140	140	140
Total stress	2,260	4,020	5,600

This can be avoided by hollowing out the abutments, as shown in Fig. 2.

Having had unusual opportunities to observe the phenomenon of shrinkage, M. Freyssinet believes that the values ordinarily assigned to shrinkage and expansion due to alternate drying out and wetting are much too high. In reality, shrinkage fluctuates about a mean value, largely dependent upon the climate, of from 0.0002 to 0.0004, by amounts which nearly compensate for slow changes in temperature. Rapid variations of temperature should not cause concern, as they create stresses only about one-half or one-third of the theoretical total difference between maximum and minimum stresses.

For these reasons, when a rational method for partially compensating rib shortening has been adopted, the computed stress due to these effects is reduced to values lying between 150 and 225 lb. per sq. in., and the use of hinges is not justified.

LATERAL STIFFNESS AGAINST BUCKLING

Since the tendency of arches to buckle transversely is aggravated in long spans and calls for increased dimensions which are not necessary from other points of view, the phenomenon warrants considerable study. It is felt that such initial tendencies can be largely offset or corrected at the time the arch is adjusted by jacks to the optimum stress condition. It is also helpful to flare the arch laterally as it approaches the supports, perhaps splitting it into two parts so as to permit the suspended deck to pass between the two branches. This method is shown in Fig. 3.

Because of the importance of this problem of buckling, complete scale model studies should be made to determine the degree of transverse stability obtained in the design. From his studies of the phenomenon, M. Freyssinet concludes that a hollow arch of uniform width will have an entirely satisfactory transverse stability if the width is $^1/_{36}$ of the span, and that this ratio may be reduced to $^1/_{60}$ at the crown when the arch is considerably flared at the supports. The crown thickness of a flared tubular arch may be reduced to $^1/_{80}$ of the span, or even less, if the depth at the springing line is increased.

TIMBER ARCH CENTERING PREFERRED

The chief difficulty in the construction of long-span concrete arches is in the construction of the centering. For a number of years M. Freyssinet has advocated a method of pouring the concrete in successive layers or stages. The center then need only be strong enough to support its own dead weight, wind forces, and the weight of the first stage of concrete. This, when it has hardened, will support the next stage, and so on. This plan was followed in the Albert Louppe Bridge with entire success. The first stage consisted of the intrados slab; the next stage, of two of the four vertical walls; the third, of the remaining two vertical walls; and the last, of the extrados slab.

Centers may be made of steel, reinforced concrete, or timber. When the first two are used, it is sometimes possible to incorporate them into the final work, but this is only of advantage when the stress which the material carries as a result of its special rôle as a center is first removed in some way. The fundamental economies

ARCH CENTERING BEING FLOATED OUT FROM UNDER THE FIRST SPAN
A 560-Ft. Wooden Frame with Laminated Deck

involved in the center itself are much more important, however, and in M. Freyssinet's opinion, timber, particularly spruce, is the most economical material for these huge auxiliary structures.

His reasons for preferring spruce are that it is easily worked, has a specific weight comparable to a steel having an elastic limit of 170,000 lb. per sq. in. and a specific cost lower than that of steel. It can be protected against rotting and made fireproof. Furthermore, it can be fashioned in such a way as to make it quite resistant to transverse buckling. This is accomplished by laminating the deck upon which the concrete is to be placed. The planks in each lamination are laid diagonally, at an angle of 45 deg. to the main axis, and those in the next layer are placed at right angles to those in the layer below. Each layer is securely spiked to the underlying one. He has used this kind of center for several important arches since 1913.

Form Work for Albert Louppe Bridge

For the Albert Louppe Bridge the centering was in reality a huge wooden arch of 560-ft. span. Its extrados was formed of spruce planks arranged in layers as previously described, while its intrados consisted of a timber framework. The extrados and intrados were connected by a system of timber bracing. Some idea of the size of this centering may be gained from the fact that it contained 250,000 board ft. of spruce and 15 tons of steel spikes.

The maximum estimated stresses in the centering were as follows:

Dead load of centering alone	140 lb. per sq. in.
Load caused by first stage—bending not included	1,140 lb. per sq. in.
Peak stresses under full dead load of arch, bending included, with wind stresses and stresses caused by concrete shrinkage added	2,140 lb. per sq. in.

Even after the center had been used three successive times, it was not possible to discover the least trace of permanent deformation in the timber. It is concluded that the customary working stresses for spruce, about 1,000 lb. per sq. in., may be safely doubled when timber of good quality is used, if it is not subjected to serious shearing stresses.

Wind Action a Limiting Factor

It is the action of the wind that really limits the possible span of this centering. Preparatory to the construction of the Albert Louppe Bridge, a careful wind tunnel test was made on a 1:100 scale model of the center, but the results did not check with the computed values and with subsequent experience. Therefore M. Freyssinet recommends instead that studies be made on larger models which can be tested under transverse loads comparable to the wind forces expected.

From experience obtained on the Albert Louppe Bridge, it is estimated that the centering for a 3,280-ft. (1,000-m.) arch will require about 6,300,000 board ft. of timber and will weigh approximately 15,000 tons. The centering for a 4,920-ft. (1,500-m.) span would weigh about 60,000 tons.

Various methods of placing centers have been used in France. Frequently centers have been built in two or three parts and maneuvered into position by barges or by other means, and then raised into position by cables attached either to the concrete arch supports or to portions of the center already erected.

Where possible, the best method is that used in the construction of the Albert Louppe Bridge. The center for this structure was built with its two ends resting on large barges. It was floated into position under the cantilever arms of the piers, and raised by means of steel slings operated by hydraulic jacks until it was snug against the under side of the pier arms. The ends of the center were prevented from spreading by horizontal steel cables adjusted by hydraulic jacks.

When the centering had been finally adjusted to

The Completed Structure Spans the Elorn at Plougastel
Designed to Carry a Standard Gage Railroad and a Highway

optimum stress conditions, a cushion composed of hooped concrete prisms was poured between its ends and the cantilever pier arms in such a way as to make them receive the entire thrust of the centering when the concrete arch was poured. Decentering was effected by the progressive destruction of these prisms. This was done with great caution as it was necessary to dissipate in this way the enormous energy stored up in the centering.

Designed and Constructed by the Societe des Enterprises Limousin (Freyssinet System)

PROVISIONS MADE FOR A RAILROAD TRACK
Below the Roadway of the Albert Louppe Bridge

CENTERING FOR SINGLE-SPAN CONSTRUCTION

In single-span construction, where it is necessary to use the centering but once, the portion to be placed by flotation may be considerably reduced in weight. In such a case the centering is built in three parts. The two side segments are cantilevered out from, and guyed back to, the skewbacks, as shown in Fig. 2.

If the previously described method of placing the concrete in stages is used, the middle section of the centering may be reduced to a skeleton just sufficient to carry the first stage and to resist the effects of the wind. The use of an overhang of one-tenth of the span will reduce the weight of the central part to 1,000 tons for a span of 1,640 ft. (500 m.), and to 5,000 tons for one of 3,280 ft. (1,000 m.).

The conception which M. Freyssinet has finally formed of spans between 1,640 and 3,280 ft. (from 500 to 1,000 m.) is that of concrete tubes reinforced against lateral expansion but with little or no longitudinal reinforcement. Such spans could be constructed in a great number of layers or stages upon very light centers, the essential function of which would be to resist wind forces until the concrete had attained sufficient strength of its own.

These arches, narrow and slender in comparison with their length, would flare considerably near the supports in order to provide maximum lateral stiffness and to reduce the unit pressures on the foundations. This flare would be reminiscent of the base of the Eiffel Tower.

The dimensions of the crown cross section of such arches are almost entirely dependent on the span length, and even a considerable variation in the live load has little effect upon them. They are thus seen to be particularly advantageous where foundation conditions are relatively simple and where heavy loads are to be carried.

The total cost of an arch having a span of 3,280 ft. (1,000 m.) with foundations on bedrock 40 ft. below high water, and carrying two decks, whose combined width is 165 ft. and whose length is 4,920 ft. (1,500 m.), has been estimated by M. Freyssinet. His estimate, based on conditions in France in 1930 and expressed in dollars (assuming an exchange rate of 25 francs to the dollar), is as follows:

Foundations and skewbacks	$3,200,000
Arch rib, 3,280 ft.	4,700,000
Center	2,700,000
Superstructure (decks), 4,920 ft.	1,900,000
Total	$12,500,000

He points out that such a span, with its safety factor of 5, would cost less than half as much as the Hudson River suspension span (George Washington Bridge, New York), whose factor of safety would scarcely exceed 2 for loads of the same order, and whose maintenance costs will be considerably higher than those of the concrete span.

According to M. Freyssinet, the cost of concrete arch spans over 656 ft. (200 m.) long will be about two-thirds the cost of a comparable steel span having less than half the factor of safety. This is for average live loads. Where loads are exceptionally heavy, the cost may be reduced to one-third.

This being so, he questions why the development of reinforced concrete has been so slow in comparison with steel bridges and why it has taken 20 years to increase the length of the record span from about 300 to 600 ft. The answer to this question lies, he believes, in the fact that the development of steel spans was coincident with that of the railroads, whose needs they satisfied as no other material previously had been able to do. Having found a material so satisfactory, the railroads encouraged in every way the unusual designs conceived by specialists in structural steel.

CONCRETE DESIGNS DEVELOPED UNDER HANDICAPS

Reinforced concrete, however, developed under very different conditions. Construction needs were already satisfied, and there were numerous splendid examples of steel bridges. Any new material was opposed by the steel bridge industry—an industry which for a century had been impregnated with the methods created by a galaxy of great men. Its personnel and capital, aided by inertia, have defended it fiercely against the competition of reinforced concrete.

In order that a long-span bridge of reinforced concrete should have preference over a steel structure, it does not suffice that it offers more advantages and guarantees at half the cost. Choice of the concrete span requires exceptional farsightedness and courage on the part of the men who make the decision. For a number of years it will therefore be necessary to struggle to create little by little examples of concrete bridges, to change the attitude of the public, and to accustom it to the simple and monumental beauty of design which concrete makes possible.

Supplementary Methods of Stress Analysis

Problems in Complicated Structures Solved Experimentally

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Mathematical solutions of the stresses in simple engineering structures can be made with reasonable exactness, but a full theoretical analysis of the complex stresses in intricate structures is only possible in a few special cases. Elsewhere experimental methods must be resorted to, such as the use of strain gages, the testing of models made of various materials, the method of analogy, the study of yield lines on the surface of members stressed to the elastic limit, or the examination of photo-elastic images produced by passing polarized light through stressed models. Good judgment is required in choosing the proper experimental method for verifying or checking the mathematical analysis used. In this article, Professors Gilkey and Bergman describe the various experimental methods of attacking complicated problems of stress distribution.

Originally the proportions of structures were determined by estimation, trial, and experience. In succeeding designs, elements that showed signs of weakness were strengthened and those that appeared to be unnecessarily strong were lightened. As knowledge of the action of structures under load increased, this rule-of-thumb method of proportioning was to a large extent superseded by more exact methods, in which dimensions were determined by mathematical analysis based on the principles of mechanics and the properties of materials.

There are, however, two groups of designs in which rule-of-thumb methods still persist. In one of these, proportions are determined largely by other considerations than those of strength. Thus, in the design of a residence, the sizes of joists, studding, and flooring are governed to a large extent by the stock sizes of lumber, and the architect specifies such sizes as judgment and experience have found suitable.

More important is the second group, in which are included all structures or details of structures which are not designed rationally because no rational method of design has been developed for them. While our knowledge of the action of bodies subjected to simple states of stress is reasonably complete, as yet we have been able to obtain analytical solutions in only a limited number of special cases in which complex states of stress are involved. This absence of exact solutions has been made up for in part by various experimental methods of obtaining information regarding the distribution of stress. Some of these methods yield quantitative solutions, while others give only qualitative results.

Measured Strains Show Distribution of Stress

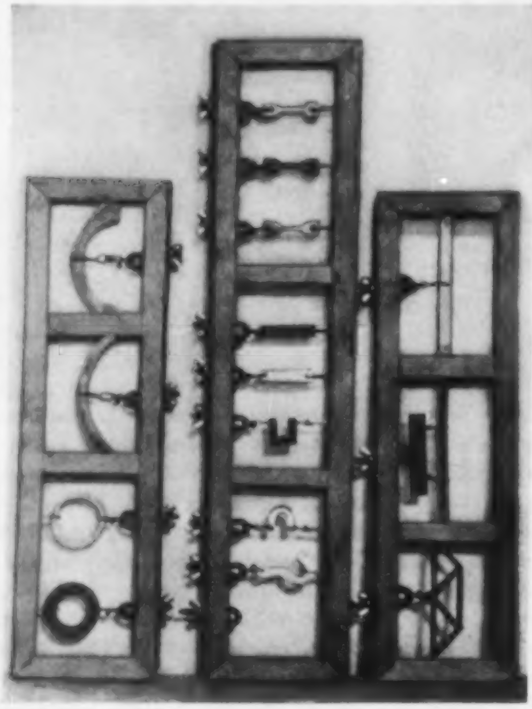
The most widely used experimental method of studying stress distribution in a member involves the measurement of the strains set up in it. Various types of strain gages have been developed during the past quarter of a century for this purpose. If the proportional elastic limit is not exceeded, the average stress can be obtained by multiplying the unit strain by the modulus of elasticity of the material. But unit strains are measured only on the surface of the body and the stress obtained represents the average of all the values secured over the length in question. Since the stress may change rapidly from point to point in the vicinity of abrupt changes in shape or section of the member or near the point of application of concentrated forces the average stress in a gage length may differ considerably from the stresses which exist from point to point along the gage line. A high stress intensity over a very short length of member might well produce an unsafe condition, although, because of the shortness of the section involved, the total strain might be very small. Of this nature are the local stresses that constitute a hazard in any type of loading and serve as focal centers from which radiates the progressive cracking so characteristic of fatigue and impact failures. In impact loading, high energy concentrations are brought to bear at such points, while in fatigue loading a slower but progressive tearing or slipping occurs.

In spite of the fact that local stresses are often the "bête noire" of the designer because of the difficulties of anticipating them and designing against them, they are indispensable to the fabricator and builder. It would be impossible to dig, chop, saw, grind, nail, or machine, were it not for the fact that by applying high local stresses a material can be made to fail at predetermined places without damaging it elsewhere. The benefits of local stress, however, are more for the constructor than for the designer. From the standpoint of the designer or detailer—localized overstress is a thing to be detected and avoided.

In the attainment of these ends ingenious and unusual methods and devices are often helpful. It has been only during recent years that such supplementary aids have gained prominence in the effort to ascertain the stress distribution or variation from point to point in a member of more or less complex form or loading. Although complex stress conditions do not necessarily indicate local overstresses, they are likely to include them, for it is the undetected overstresses that constitute the hazard in any stress system that cannot be analyzed adequately.

Because of the importance to the engineer of these newer methods of stress analysis, the last meeting of the term for the course in Materials Testing Laboratory at

the University of Colorado consists of a lecture on experimental methods of stress analysis. Special emphasis is placed on the photo-elastic method, which is illustrated with images of bodies under stress projected on a screen. The mental pictures carried away by the student from the



Celluloid Models for Stress Analysis by Polarized Light

demonstration of the photo-elastic method for indicating stress distribution in members with holes, notches, and fillets, in variable sections, angle sections, hooks, rings, beams, and trusses should help him in future design work to avoid shapes of sections which lead to undesirable concentrations of stress.

This demonstration should be a help also in the acquisition of a mental picture of the stress condition of a body subjected to complex types of loading, a picture obtained with great difficulty from mathematical concepts alone. Although only elementary treatment has been attempted in this lecture, so much interest has been shown in it by practicing engineers and others who have heard it that it is believed it may prove equally interesting to many of the readers of Civil Engineering.

In general, supplementary methods of stress analysis can be grouped under four heads: methods making use of models, methods involving yield lines, methods of analogy, and photo-elastic methods.

"BRITTLE-MATERIAL" MODELS

The use of models as an aid in the design of structures has become more and more common in late years. A few of the more prominent types will be discussed. The plaster-model method—an application of the so-called "brittle-material" method—is described by F. B. Seely and R. V. James in Bulletin No. 195 (1929) of the University of Illinois' Engineering Experiment Station, entitled "The Plaster-Model Method of Determining Stresses Applied to Curved Beams." According to this method, a model of the more or less complex member in which the state of stress is to be studied is built up of a "brittle" material that has practically a straight-line stress-strain curve up to its rupture point. A companion model is made of the same material as the model and of such form that the stress due to a given load can be computed analytically. The model and the companion specimen are then tested to failure. As explained by Messrs. Seely and James:

> The test of the simple shape gives approximately the ultimate strength of the material and the test of the model gives, with a fair degree of accuracy, the load which produced this ultimate stress in the most stressed fiber of the model; from these values the relation between load and maximum stress is obtained.

The fact that the brittle material gives a straight-line stress-strain diagram makes it possible in many cases to determine in addition the approximate distribution of the stresses.

Influence lines for reactions or moments in structures can also be obtained by means of elastic models proportioned so that Maxwell's principle of reciprocal deflections can be applied. Several different types of instruments are available for the application of this method. These have already been employed in the analysis of a number of complicated structures and have demonstrated their usefulness.

Writing on the use of models in this connection, J. A. Van den Broek, Assoc. M. Am. Soc. C.E., on page 215 of his book on the *Elastic Energy Theory*, says:

> It may be difficult to find suitable material and difficult also to construct the model. Once constructed, however, no complexities due to the larger number of redundants, to irregularities at corners, enter the problem to detract from the value of the result. The answer obtained from the elastic curve of a well constructed model of a complicated structure is likely to be in much better agreement with the theory of elasticity than one obtained by mathematical process. In fact, the result obtained from the model would give expression to parts of the theory of elasticity which, as yet, we are unable to formulate mathematically.

The behavior of an actual structure under load may be investigated by means of a model which represents the structure on a reduced scale. Loads simulating those on the actual structure are applied and the deformations and

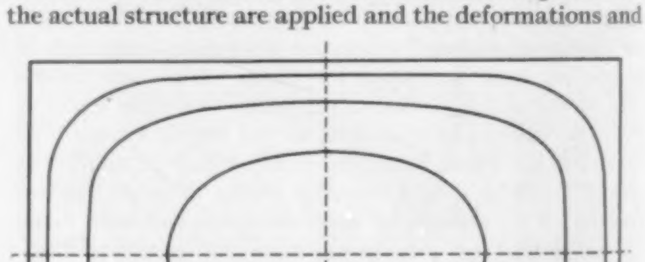


Fig. 1. Contour Lines for a Rectangular Section As Determined by the Membrane Analogy Method

deflections of the model are measured. As recent examples of this type of investigation may be mentioned the tests on the Stevenson Creek Arch Dam conducted by the Engineering Foundation; those on models of the

Stevenson Creek, Gibson, and Hoover dams carried out by the U.S. Bureau of Reclamation; and those of half-scale models of compression members of the Washington Memorial and Kill van Kull bridges made by the Port of New York Authority.

The material of the model, its scale, and the loads applied to it, should be such as to fulfill the necessary conditions of similarity so that a direct relationship will exist between the behavior of the model and that of its prototype. This direct relationship is especially important in the fields of hydraulics and aeronautics, where structures are subjected to dynamic action.

This subject is presented by Benjamin F. Groat, M. Am. Soc. C.E., in a paper on the "Theory of Similarity and Models" in PROCEEDINGS for October 1930 and in his closing discussion in the same publication for August 1931. In a discussion in PROCEEDINGS for February 1931, A. V. Karpov, M. Am. Soc. C.E., treats these conditions of similarity for models of dams. This was also the subject of the article, "Building and Testing an Arch Dam Model," by A. V. Karpov and R. L. Templin, in the January 1932 issue of CIVIL ENGINEERING.

METHODS OF ANALOGY APPLICABLE

Analysis of stress by the method of analogy depends on the similarity in form between the partial differential equations which express the stress in a member and the equations which express some physical phenomenon which is capable of experimental determination. The membrane analogy is based on the fact that the equations which determine the stress distribution of an elastic bar in torsion are identical in form with the equations of the surface of an elastic membrane of the same shape under uniform lateral pressure.

In practice, the membrane consists of a soap film stretched over an aperture of the same shape as the cross-section of the bar and subjected to a difference in air pressure on its two surfaces. The slope of the surface is measured at various points; contour lines are plotted; and the volume between the surface and the plane of its outline is determined. From these data the direction and intensity of the shearing stress at a point in the bar and the torque on the bar may be computed. The accompanying photograph of plaster casts formed on a rubber membrane placed over apertures of various shapes shows approximately the shape of the soap film for different cross sections. The approximation is due chiefly to the fact that the deflection of the rubber membrane was large compared with its transverse dimensions.

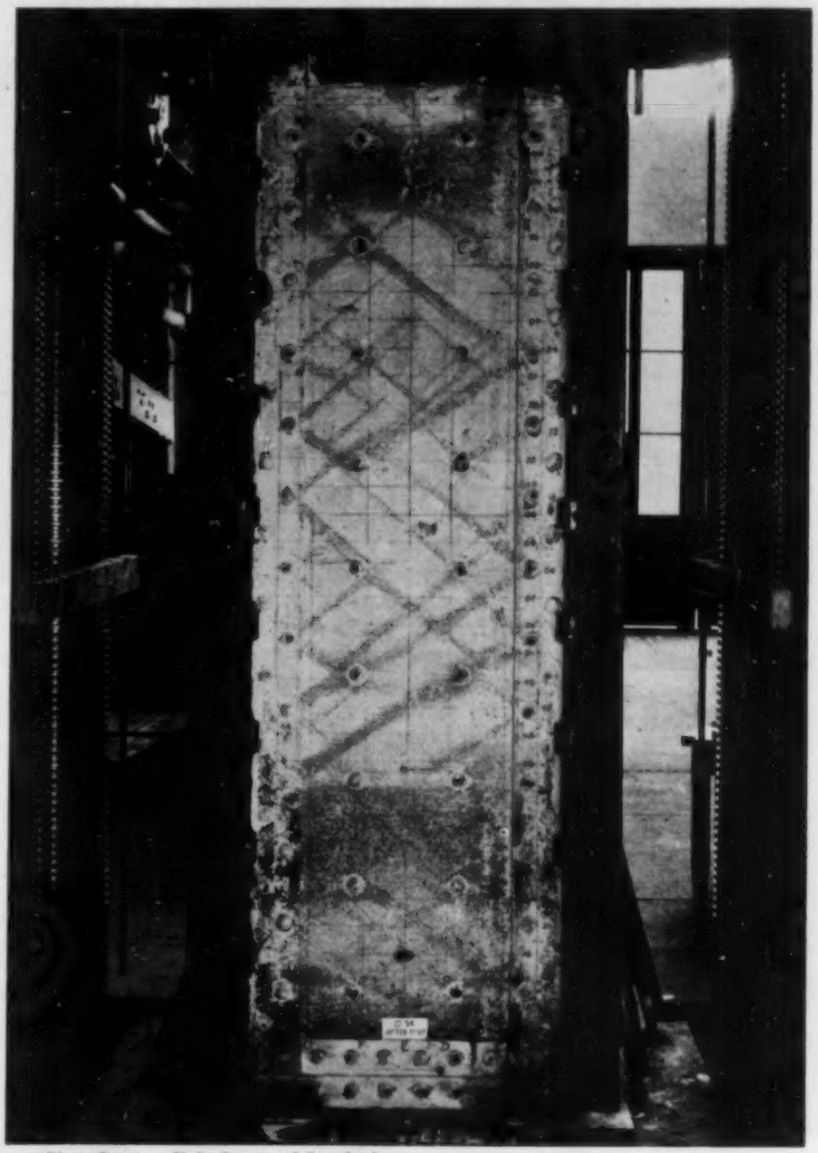


Photo Courtesy U.S. Bureau of Standards

YIELD LINES ON A COMPRESSION MEMBER OF THE DELAWARE RIVER BRIDGE

PLASTER CASTS ILLUSTRATING THE MEMBRANE ANALOGY METHOD OF SOLVING TORSION PROBLEMS

Contour lines for a rectangular section are shown in Fig. 1. The stress is inversely proportional to the distance between contour lines so that the highest values of stress occur where the contour lines approach one another most closely. At the corners the shearing stress is zero, since the surface of the membrane lies in the plane determined by its boundary. The highest intensity of shearing stress occurs in the outside fibers at the middle of the long side of the rectangle.

Hydro-dynamical analogies are based on the mathematical relation which has been found to exist between the motion of a frictionless fluid and the stress in a twisted bar. An experimental method has been developed for the

torsion of a shaft of variable diameter using an analogy between the distribution of electrical current in a plate of variable width and thickness and the distribution of shearing stress in a twisted shaft of variable diameter.

A large plastic deformation occurs along planes of maximum shearing stress when a material having a definite yield point approaches its yield-point stress in tension. This deformation makes itself evident by lines of slippage, which can easily be seen if the surface of the material is polished. These lines, called Lueders lines, can be used to indicate the points of highest stress concentration in a member.

If the surface of a specimen is coated with a film of brittle material, such as a wash of white portland cement, the flaking of the film indicates the points where the yield-point stress is reached as well as the general distribution of concurrent yield-point stresses. The yield lines which developed in a compressive test of structural members of the Delaware River Bridge tested at the Bureau of Standards are strikingly shown in one of the accompanying photographs.

Data of a similar nature can also be obtained by ruling the surface of the member to be tested into squares and noting their distortion under load. This method is more effective if the specimen is made of a highly deformable material like rubber. However, when rubber is used care must be taken in interpreting the results because of the relatively large deformations produced.

In 1816 Sir David Brewster showed that a transparent isotropic material under stress has the property of double refraction, and when viewed in polarized light under proper conditions shows brilliant color effects due to the stressed condition of the material. This phenomenon, the basis of the photo-elastic method of stress analysis, is explained in the article "Recent Advances in Photo-Elasticity," presented by Max M. Frocht before the Mechanics Conference of the American Society of Mechanical Engineers at Purdue University, on June 15, 1931.

An ordinary beam of light may be considered as consisting of vibrations in the ether which are transverse to the direction of the beam and which occur at all azimuths. Such a beam of light will show no indications of stress in a transparent material. However, if the light is passed through a polarizer, the rays which emerge will all have the same plane of vibration. If these are now passed through the stressed material and through a suitable arrangement of lenses and prisms and thrown on a screen,

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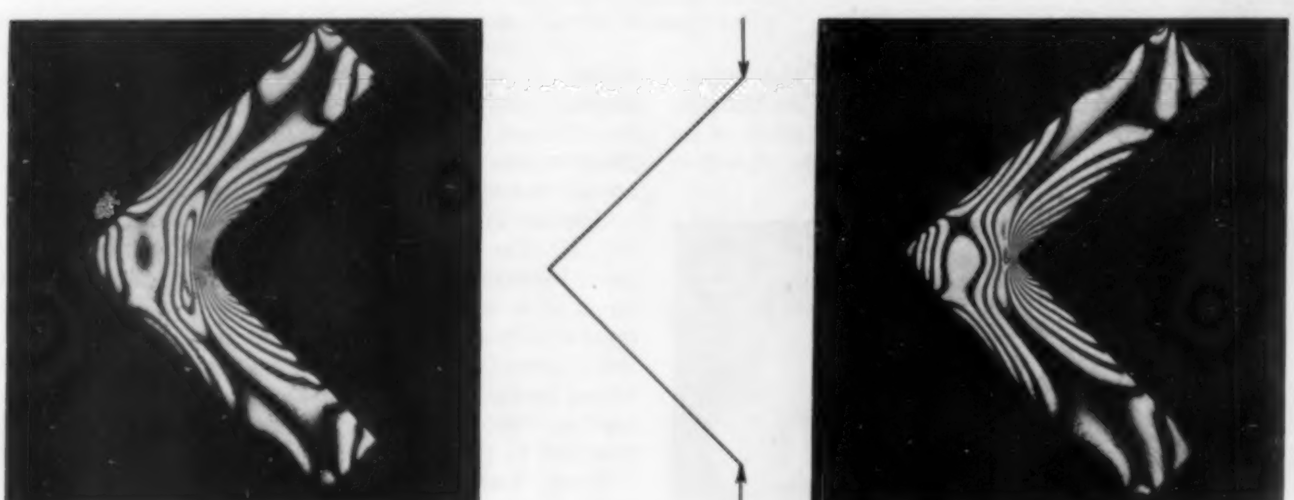
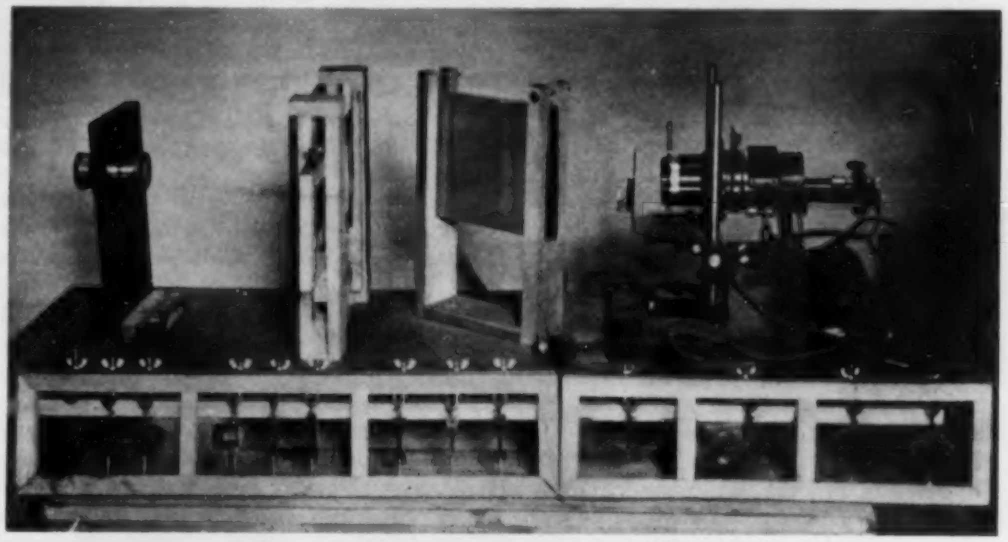


Photo Courtesy American Society of Mechanical Engineers

FIG. 2. STRESS CONCENTRATION IN ANGLE SECTIONS WITH AND WITHOUT FILLETS

a colored image of the model will be produced from which the distribution of stress in the specimen can be visualized. The comparatively simple polarized-light apparatus used at the University of Colorado is illustrated.

If monochromatic light or light of a single wave length is used, the image will consist of alternate black and white bands. The bands produced by monochromatic light in angle sections with and without fillets are shown in Fig. 2, and those in a beam under central loading are indicated in Fig. 3. The bands are closest together where the greatest change in stress distribution occurs. There is no difference in the appearance of the bands showing tension and those indicating compression. The stress distribution in Fig. 3 appears to be in close agreement with that determined by the theory of flexure, except near the concentrated load, where local stresses plainly show.



POLARIZED-LIGHT APPARATUS AT THE UNIVERSITY OF COLORADO

The material used for models should be transparent, isotropic, and free from initial stress, and should have a straight-line stress-strain curve over the loading range. The materials commonly used are celluloid and bakelite, but bakelite should be annealed to remove initial stress. The stress distribution is independent of the physical

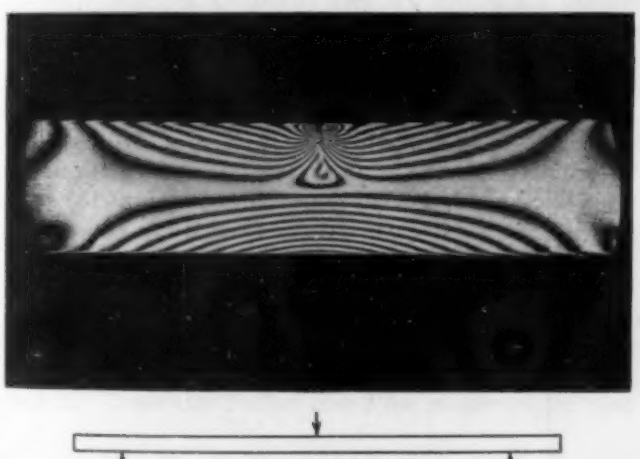


Photo Courtesy American Society of Mechanical Engineers

FIG. 3. STRESS DISTRIBUTION IN A BEAM LOADED AT MIDSPAN

constants of the test material within its elastic range so that the results obtained can be applied to ordinary structural materials. In other words, elastic materials resemble one another in the nature of their response to stress, so that qualitative comparisons are valid. The method is applicable only to one-dimensional or two-dimensional states of stress. The specimen may be a plate of any shape, but it should be of uniform thickness and the loads should act in the plane of the plate.

In those cases where an analytic solution is possible the stress distribution shown by the photo-elastic method is in agreement with theory. A study of the images of loaded members shows that high stress intensities occur in the vicinity of sharp corners and that fillets or gradual transitions tend to reduce these intensities. Such high stresses can sometimes be reduced by cutting away material so as to obtain a more gradual change of shape of the specimen.

The stress at the base of a crack may be very great, since a crack constitutes a very sharp reentrant corner. No tool-made corner can be truly sharp because the sharpness of a cutting edge is only relative. On the other hand, the base of a split or crack in most brittle materials does have the true elements of sharpness.

ENGINEERING JUDGMENT IMPORTANT FACTOR

The inherent limitations of methods involving analogies and comparisons should not be overlooked. While the methods are based on the similarity of action of model and prototype, it must not be forgotten that this similarity is not complete. There may be differences in scale, in material, in physical properties, such as modulus of elasticity or Poisson's ratio, or in the loading conditions to which the model and its prototype are subjected. Whatever the differences may be they ought to be recognized and considered, and if possible corrections should be made in the results of the tests to take care of their effect. Above all, the element of engineering judgment—and by this is meant neither immature guesswork nor seasoned bias—must enter into any complex analysis of stress, whether the method of analysis be mathematical or experimental. In new or important work of a complicated nature, the engineer should be cautious about accepting too readily either mathematical or experimental results until each has been checked against the other.

In closing, the writers desire to acknowledge their indebtedness to the following men, all of whom have contributed in one way or another the kind of suggestive stimulus that this paper is intended to offer: H. F. Moore; F. B. Seely; M. L. Enger, M. Am. Soc. C.E.; Fredrik Vogt, Assoc. M. Am. Soc. C.E.; J. L. Savage, M. Am. Soc. C.E.; W. C. Huntington, M. Am. Soc. C.E.; H. L. Whittemore, L. B. Tuckerman, and R. H. Canfield.

Sugar Plantation Engineering

Reducing the Cost of Sugar Production in the Dominican Republic

By W. E. Land

Junior American Society of Civil Engineers

Formerly Assistant Civil Engineer, South Porto Rico Sugar Company, New York

Many young civil engineers are initiated into their chosen work in the tropics, where construction work may combine modern practice with primitive methods and where mechanical equipment cannot compete with cheap native labor. In this article Mr. Land describes the reconstruction of the 80-mile narrow-gage railroad system on the property of the South Porto Rico Sugar Company, at Yngenio Santa Fe, to improve grades and alignment. A million dollars spent on railroad reconstruction reduced the previous cost of $1.20 per ton for transporting sugar cane to the mill to 28 cents per ton in 1929. Other improvements in the program consisted of open-ditch drainage wherever required. At plantation headquarters was built a modern sewage collecting system discharging into septic tanks; rolled stone roads were surfaced with oiled caliche, wells and water systems constructed, housing facilities improved, and a 9-hole golf course provided. Costs for various parts of the program are given.

Yngenio Santa Fe, one of the plantations of the South Porto Rico Sugar Company of New York, lies northeast of San Pedro de Macoris in the Dominican Republic. However, the company owns practically all the island lying east of Rio Soco between the Caribbean Sea and the mountains south of El Jovero. The plantation, Yngenio Santa Fe, shown by shaded lines in Fig. 1, comprises approximately 60,000 acres of rolling, fertile tropical land. The country immediately surrounding the main batey, or settlement, at Santa Fe is very rocky but has been under cultivation for years.

In order to appreciate the improvements made on this property, it is necessary to know something of the conditions that existed before it came under American ownership in 1926. The only commendable work done by the former organization was the construction of two railroad bridges. One of these, a 250-ft. steel truss bridge crossing the Soco River, is illustrated. The other, which is shown in Fig. 2, is a 350-ft. structure of steel plate girders, divided into five spans, which bridges the Arroyo Guasa. Each of these streams is over 100 ft. below the top of the bridge rail and, as is usual in the tropics, is very treacherous during the rainy season.

The railroad, of 30-in. gage, which had been constructed piece by piece as new land was put under cultivation, had very bad alignment and steep and irregular grades. At certain places on the line the track changed grade every three or four hundred feet. Seven locomotives were required to do work that can now be done with three. One wreck alone had cost $50,000.

Transportation of cane to the sugar mill, the chief purpose of the railroad, was costing $1.20 per ton. Upward of $1,000,000 was spent during the years from 1927 to 1929 on the improvement and extension of the narrow-gage railroad system. The enlargement of the sugar mill to a capacity of 2,700 tons of cane per day, together with the many other improvements to the property—including the construction of 500 houses, and of drainage, sewerage, and water supply systems—basic property surveys, and the development of additional cane acreage, cost another $1,000,000. Transporting the crops of 1928 and 1929, after the railroad had been reconstructed, cost only 28 cents per ton.

North of the Arroyo Frio bridge a new location for the railroad, giving better alignment and grades, was found within a mile north of the old route, and a cut which had cost the former owners $50,000 was entirely abandoned. A railroad yard at Amador, having a capacity of 240 cars and 8 locomotives, was constructed half-way between the main section of the developed property and the sugar mill at Santa Fe. This yard required the realignment of 4,700 ft. of track, and the construction of 8,000 ft. of siding at a cost of about $57,000. In some sections of the railroad the grades were as high as 3 per cent. The maximum or limiting grade on the line is now 1.13 per cent. Where the required raising of the track was not excessive, only rock ballast was used. In fact,

Bridge Over the Rio Soco
A Narrow-Gage Structure of 250-Ft. Span

Amador Yards Providing Storage for 240 Sugar-Cane Cars
Buildings Are the Permanent Quarters for Trainmen

in some places the track now has as much as 4 ft. of such ballast under it.

A 40-ft. steel plate girder bridge over the Arroyo Frio between the Amador yards and the larger cane areas was lifted 3 ft. and rotated horizontally through an arc of about 7 deg. to meet the new grade and alignment. As the lifting progressed with the aid of track jacks resting on the bridge abutments, cross ties were slipped, one after another, under the ends of the girders. Then by means of crowbars and jacks the span was skidded to the new alignment.

Cane trains coming from the larger cane area in the Campina, shown in Fig. 2, are limited to 50 cars until they reach the Arroyo Frio. Here they are broken and taken into the Amador yard in two sections. Two locomotives are required for each section from Amador to the sugar mill.

All work was done by contract at unit prices based on a rate of 80 cents per day for labor. For example, the unit pay on excavation was fixed so that a good worker could make this amount. In addition, however, a small sum should be added to allow for quarters furnished free by the company. The price paid for the individual contracts depended on the judgment of the engineer as to the difficulties of the work.

On the first six kilometers of the railroad, between the Rio Soco and the Campina district, heavy excavation was encountered. Dirt was moved in Western dump cars by one of the small locomotives. The price paid for excavation varied from 30 cents to $1 per yard. All excavation was done with pick and shovel by local labor. In this section of the line considerable rock was found, which required the use of dynamite and increased the cost to the maximum amount.

CONSTRUCTING RAILROAD NEAR ARROYO LUCAS

Ballast was delivered on the job for $1 per cu. yd. The securing of ballast in the construction of any of the Santa Fe lines did not involve a serious problem as the southern district of the property is literally covered with rock of volcanic formation. Natives were paid from 25 to 35 cents per cu. yd. for picking up this ballast rock by hand and piling it along the cane roads or railroad. It also makes very good aggregate for concrete. On one job where it was used for this purpose, it cost $1.50 per cu. yd., which sum included crushing the larger rocks with sledge hammers by Haitian labor.

Ballast was moved from the field by bull carts. A native was supplied with from six to eight carts and other necessary equipment. Any ropes, chains, or other smaller articles were charged against his account, and a deduction for their cost was made from his pay check each pay day. The bulls and carts were also charged to him. Upon the completion of his contract these were returned, but he was required to pay for any damage done to the carts, and also for the bulls in case they had been injured or killed. The number of bulls killed during a year's operation of a sugar estate is really surprising.

On all construction either mahogany or bayahonda ties were used. These were contracted for at from 75 cents to $1.20 each, delivered to some point along the railroad where they could be loaded on flat cars. They were bored for spikes by English negroes at a cost of two or three cents for each tie. On new construction 60-lb. American rolled rail was used. Track-laying contracts were made with the foremen of gangs, composed of from 10 to 20 natives. The prices paid were such that the foreman would

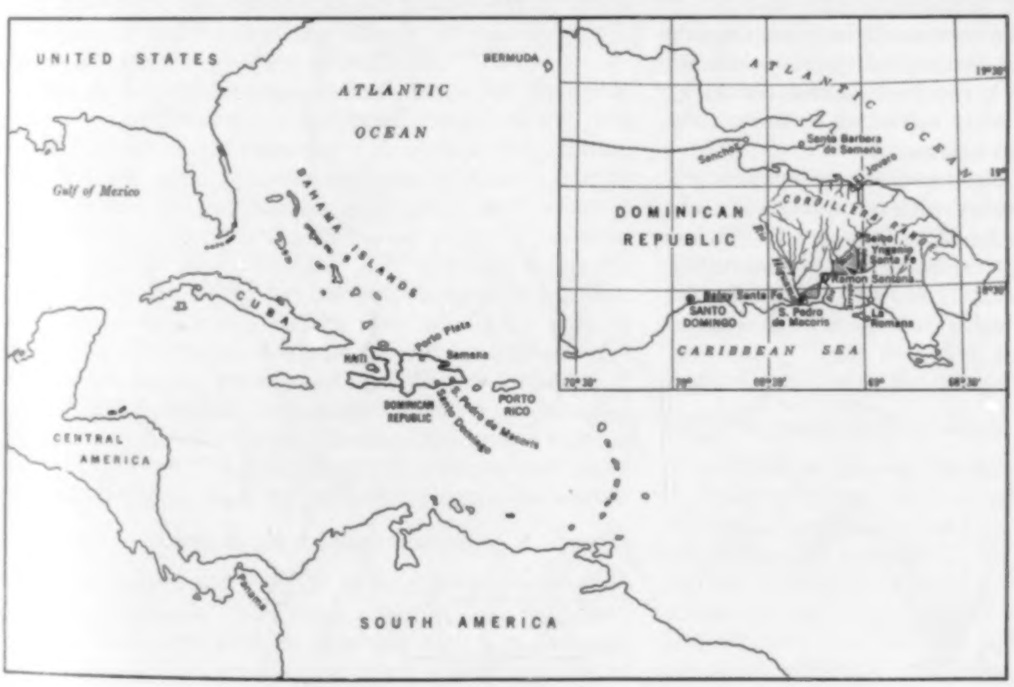


FIG. 1. MAP OF THE DOMINICAN REPUBLIC
With Location of South Porto Rico Sugar Company's Property

earn $1 per day. Assistants working with him as spikers and tampers of ballast could earn 70 to 80 cents per day.

After the original railroad reconstruction program was completed, 8 km. of new line were located and constructed from the Campina district north to Arroyo Lucas. This work was done during the summer, when plenty of labor was available.

SURVEYOR ON RAILROAD LOCATION IN ARROYO LUCAS DISTRICT
A Party Often Consisted of 15 Men

One of the tangents in the extension was two miles long. It so happened that the location passed through a large cane area which was badly in need of drainage. The fill of 18,000 cu. yd., which was thrown up at a cost of 15 cents per cu. yd., was composed of dirt taken from the excavation of a ditch which was dug parallel to the railroad.

North of this section a 6-km. connection was built between Bejucal and Alta Gracia, in which one of the largest cuts was 1,000 ft. long and had a maximum depth of 12 ft. Excavation was contracted for with native Haitians at 25 cents per cu. yd., which included moving the dirt a distance of 2,300 ft. Immediately south of the cut was a fill 2,000 ft. long having a maximum depth of 4 ft. A track of old 30-lb. rails and old ties was laid from the deepest point of the fill to the mouth of the cut, where a switch was put in. Along the side of the excavation, which was taken out in the shape of a box 8 ft. wide, a track was laid from the switch to the top of the hill. The overburden was moved out on the side track. The track was laid from the switch through the cut as the excavation progressed. Later a small locomotive and larger dump cars were employed in widening the box section and cutting the slopes. Some of the cut would not stand up on a slope of $1^1/_4$:1 and a bench section was taken off to maintain it.

Initially, track laying was contracted for with English negroes at $3 per hundred feet, which price was later reduced to $2. Their work required careful checking, the gage being found in some instances to have been made as much as 5 in. too narrow.

On this section were required two reinforced concrete box culverts of rubble masonry with reinforced concrete top slab. One of these, designed for Cooper's E-50 loading, consisted of three 10-ft. spans carrying a 10-ft. fill, and necessitating a length of 42 ft. between headwalls. The abutments, dividing walls, and wing walls were of rubble masonry. The top slab, 15 in. thick and reinforced with old rails, was poured by hand in three sections, one day being required for the pouring of each section. The floor channels were paved with concrete.

While from a theoretical standpoint this type of reinforcing would not be satisfactory because it would result in an unbalanced design, it did provide a practical solution. After the forms were removed from the bottom of the slab, an examination showed that the reinforcing was exposed in only a few places. It was very hard to get the natives to realize the importance of properly tamping the concrete while it was being poured.

All other culverts along the line were constructed of precast concrete pipe with rubble masonry headwalls. The pipe was made in a central concrete plant operated by the engineering department. Plain concrete pipe 2 ft. in diameter cost $1 per ft. Very little trouble was experienced from breakage of either the plain or the larger reinforced pipe, and this was probably due to the care taken in placing. The dirt on either side was well tamped and kept thoroughly wet during this operation. A 15-ton road roller was passed safely over the top of one of the 2-ft. culverts where there was only 1 ft. of covering. Rubble masonry headwalls were decided upon because it was estimated that they would cost about $8 per yd., while those of concrete would cost slightly more on account of form work.

From Alta Gracia the existing tracks were relocated and extended to a point one kilometer north of the Arroyo Guasaba into a newly developed cane-field area. Across

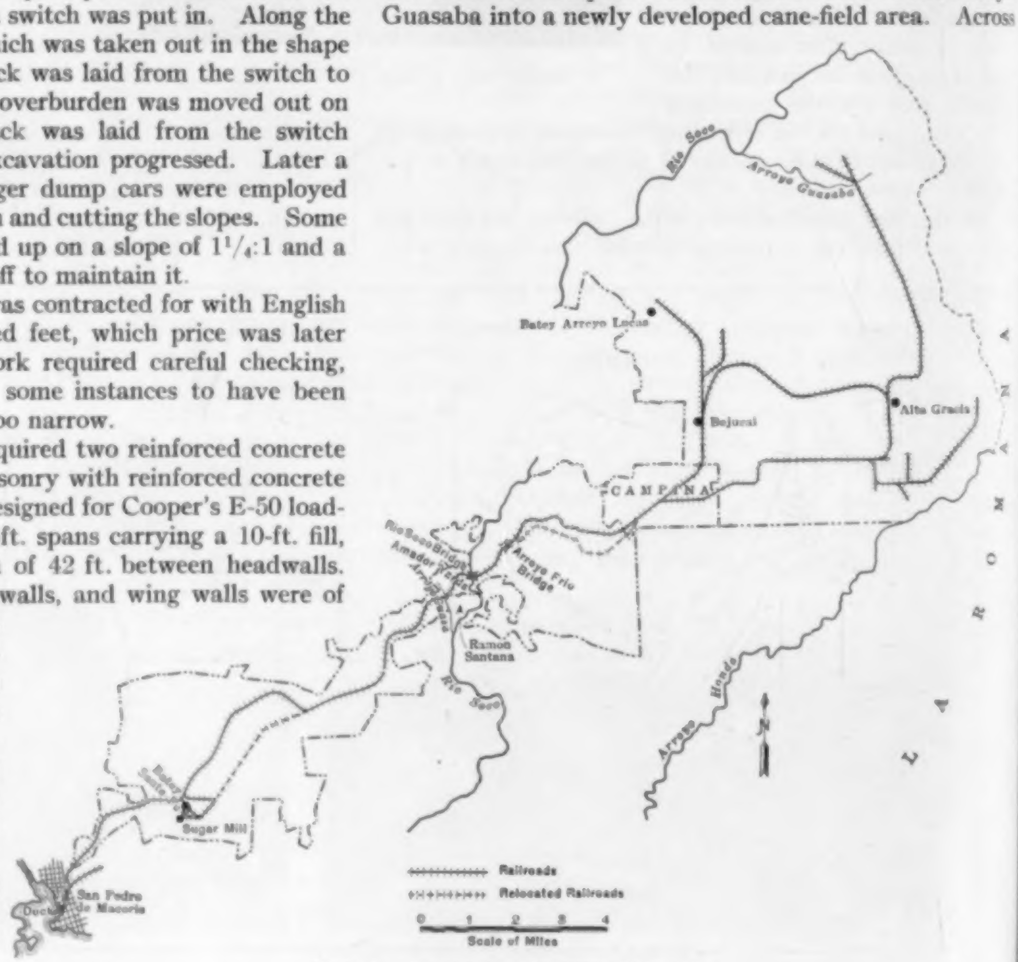


FIG. 2. DETAIL OF YNGENIO SANTA FE
60,000-Acre Sugar Plantation

the Arroyo Guasaba a 40-ft. steel girder bridge was constructed. Overhanging one side of the arroyo was a rock ledge, with its top about 20 ft. above the bed of the stream. In this ledge, with dynamite and iron bars, the natives dug out a seat for one end of the bridge. The abutment at the other side, adjoining a 12-ft. fill, was made of rubble masonry with long and very heavy headwalls. A general outline and layout of the bridge were sent to the steel company in the United States which made the girders—designed for Cooper's E-50 loading.

Torrential rains, frequently as much as 10-in., which run off rapidly, had cut through the cane fields a great number of arroyos, or small deep gulleys, which present quite a problem to the road maker during the rainy season. To build bridges across them strong enough to withstand flood conditions would require such a long and high span that the cost would be prohibitive. The best and least expensive structure that has been found satisfactory is a culvert of concrete pipe with exceptionally bulky headwalls, for unless these headwalls are carried down well below the bed of the stream they will not stand. After the dirt is thoroughly tamped around the pipe, a foot or two of small rock or gravel is placed on top. Of course it is necessary to have a dirt cushion between the rock fill and the pipe.

During flood conditions the water sweeps across the roads on top of the culverts to a depth of 20 ft. or more. In one freshet a cart and six oxen were caught at one of these crossings. Three of the oxen were found two miles below and the other three were not found at all. After such a freshet the road fill is all washed away and only the massive headwalls and concrete pipe remain. The fill must then be replaced, often several times a year.

For rough plowing of the cane fields modern machinery has replaced ox-drawn plows. The plow now in use is drawn back and forth across a field by a 1$^1/_4$-in. steel cable wound on the drums of the "steam plows," one of which operates at each side of the field. Bridges on roads were designed to carry these "steam plows," one of which is shown in an illustration. Their 28-ton weight is largely concentrated on the rear wheels.

Close to $30,000 was spent on drainage for the whole plantation. Ditches varied in depth from 2 to 7 ft., the standard being 30-in. deep and 2 ft. wide at the bottom. The contract price for excavation varied from 13 to 25 cents per cu. yd., the maximum being paid when it was necessary to move the dirt over portable track in 1$^1/_2$-yd. dump cars. Ditches any smaller than the standard size were dug by the cultivation department. In all cases, as far as possible, they were kept parallel to the cane-field lines. Because the soil eroded so easily, very small grades were most satisfactory. Slopes of more than 0.5 per cent eroded badly, and a grade of 0.3 per cent gave better results. Some of the grades were as low as 0.1 per cent, but ditches of this type required more frequent cleaning, done by the cultivation department.

SEWER SYSTEM CONSTRUCTED

A sewer system over 2,000 ft. in length was constructed at Batey Santa Fe. The pipe, made in the company's concrete plant, was 8 in. in diameter with 6-in. laterals. For the manholes a small circular pit was excavated, in which the steel forms for the 3-ft. concrete pipe were placed. Concrete was then poured and the floor of the manhole made even with the top of the sewer pipe. A slot 3 in. wide and 1 ft. long was cut with a cold chisel in the top of the sewer pipe, where it passed through the manhole.

Native laborers were paid 5 cents per joint for laying the pipe sections, which were 2 ft. long. An exceptionally good worker could lay 55 joints per day. They had the old idea, however, of "out of sight, out of mind." It was very difficult to get them to place the concrete in the joints properly so that it would not squeeze out into the pipe. They were therefore required to pull a sack full of dirt through the pipe as they went along to keep the bottom smooth.

All septic tanks were repaired and the laterals were connected into the third or second cell of each tank. A surge tank was constructed at the end of the main sewer,

Breaking a Cane Field with "Steam Plows"

which had a grade of 0.3 per cent. This tank, which was made of a 6-ft. pipe placed on top of a rubble masonry floor, was filled and discharged once each week.

Considerable trouble was experienced in digging the pipe trenches, which were uniformly 2 ft. wide, with a maximum depth of 5 ft. About 2 ft. below the surface, layers of rock were found. Where the rock was solid it could be blown out very easily with dynamite, but where there were alternate layers of rock and caliche, the dynamite merely bulged out a pocket in the caliche between the two layers of rock. On this type of excavation laborers were paid 35 and 40 cents per cu. yd. They paid for the dynamite at 24 cents per stick and for caps at 8 cents each. Natives were not allowed to do the shooting; it was done by the engineer on the job.

This caliche is a hard, white, clayey material which stands nearly vertical in a cut. For removal it must be picked and often shot. It is fine grained, containing no rock particles, and when wet it is very slippery. On road surfacing work the pieces of caliche, when dry, can be broken with the back of a shovel.

MODERN CONVENIENCES AT HEADQUARTERS

Included in this improvement project was the construction of three miles of streets in Batey Santa Fe. The surfacing consisted of 7 in. of rock and 2 in. of caliche wet down and rolled with a 15-ton roller. The surface was later oiled, and over the top was placed a thin layer of fine gravel. This type of road, which was found to hold up very well under tropical conditions, cost $1.60 per running foot for a 16-ft. width and required inexpensive repairing every four months. The same class of stone as that used for ballast was employed on this road,

and was crushed into place with a roller. Natives were paid 75 cents for placing the stone in each 50-ft. section of the rectangular excavation which had been dug out for the road foundation.

The home of each official or executive was supplied with a rubble masonry rainwater tank constructed to hold 10,000 gal. This, the only water they used for drinking, required boiling. In a great number of the smaller bateys windmills pumped groundwater for the natives and live stock. It did not seem to have any injurious effect on the natives.

In the pastures, rubble masonry water troughs were built and connected to the main pipe lines with galvanized pipe from $^1/_2$ to $1^1/_2$ in. in diameter. Square reservoirs which would hold 30,000 gal. were built of masonry with walls about 8 ft. high, plastered inside with

TEMPORARY TRESTLE FOR FILL ACROSS THE ARROYO GUASABA

cement mortar, and floored with 12 in. of plastered masonry. Several kinds of engines—including Diesel and other oil-burning types—were used to operate the pumps. Windmills were employed where only a small quantity of water was needed. Trenches for the pipe were usually from 1 ft. to $1^1/_2$ ft. deep. They were 8 in. wide and cost 1 cent per lin. ft. At the sugar mill a well 500 ft. deep was drilled and equipped with an electric pump.

Native labor was housed in buildings constructed of American pine costing $85 per thousand board feet. Local hardwood lumber of a good grade was considered worth $90 per thousand. This lumber, however, was not suitable for building purposes although it was used for furniture and was especially well adapted to the construction of bull carts.

For the construction of all houses, five standard plans were worked up by the engineering department. A typical peon laborer's house was 10 by 20 ft. Married natives were given this type of house. The unmarried natives lived in what are known as barracons. These houses were 20 by 100 ft. and partitioned into 20 rooms. The barracons constructed by the former company were built on the ground with no floor, but the new barracons were set on wood blocks well off the ground and provided with concrete floors for sanitary reasons. All foundation material was treated with creosote. The roofs were made of corrugated iron.

Senior native employees were given houses of three or four rooms. In the main batey at Santa Fe, such houses had modern sanitary conveniences and cost from $700 to $1,000. Unmarried American employees, when in the main batey, lived in the American Club, where the company ran a mess hall. The food was prepared by French negroes, who were taught American cooking. Other club houses and mess halls were operated for other classes of employees.

During the latter part of the program a 9-hole golf course costing about $4,000 was constructed. The greens were of sand with a hard caliche foundation. On one of the greens, as an experiment, the caliche was oiled. On top of this 2 in. of river sand was placed. It was found, however, that the oil held the water on the green too long, so on all other greens the oil was omitted and the water drained through the foundation. Sea sand was too fine for the surface. The fairways were planted with Bermuda grass.

Yngenio Santa Fe has a very accurate system of mapping and surveying. The main line of the railroad, which was used as a base line for all mapping, was surveyed by three different engineers. Their sets of chaining were carefuly checked, and they were required to take observations on Polaris every 3 miles. In a distance of 9 miles an error of one minute was found. Railroad surveys were required to close with an error of 1:5,000; new cane-field surveys, with an error of 1:3,000; and surveys of old cane fields, with one of from 1:1,500 to 1:3,000. In the location of streams and other topography of no great importance an error slightly greater than this was allowed. All surveys were required to close with an angular error in minutes not greater than the square root of one-half the number of transit set-ups.

Cane fields were laid out 900 ft. east and west and 450 ft. north and south. Ten fields of this size composed a *tablon* of 500 *tareas*. The *tarea* unit is 8,100 sq. ft. The fields were separated by 27-ft. roads, but where the company's land bordered on a foreign property a 50-ft. road was provided for fire protection.

The cane fields had been laid out by the old organization in all shapes and sizes. As the cane was cut during the crop season, the fields were staked according to the new layout. Considering that it would require an unnecessary length of time to run base lines all over the property, coordinates were calculated along the railroad, determining points at which the true north and south and east and west lines would intersect the center line of the railroad. In this way an engineer was able to go to any part of the property and, beginning at the railroad coordinate, stake out fields according to the new layout. One is now able to stand on some of the hills and see for miles along the straight cane-field roads.

Some of the Dominican "boys" developed into very good transitmen, but they were not allowed to conduct a party unless the engineer was present. Although they did not understand the keeping of notes, they made exceptionally good chainmen and were thoroughly familiar with the use of plumb-bobs. Some of these "boys" had been working with the superintendent of construction for 15 years.

The improvements here described were constructed under the guidance of W. T. Hennessy, Administrator, and H. C. Houston, Chief Engineer. Designs were made under the direction of S. L. Davis, Assoc. M. Am. Soc. C.E., Office Engineer; and various sections of the work were constructed under the immediate supervision of four assistant civil engineers. During the peak of the work the engineering staff in office and field numbered 14 Americans.

OUR READERS SAY

In comment on Papers, Society Affairs, and Related Professional Interests

Surveying and Mapping Data Valuable

To the Editor: In connection with the articles by Messrs. Ylvisaker and Dodds in the December issue, I should like to make a few comments on the work of the Surveying and Mapping Division of the Society. The Division, which has been in existence nearly six years, now has a membership of more than 800 and is steadily increasing in size.

I believe that, as a result of the creation of the Division, the engineering profession is placing surveying and mapping in a far higher position than these important branches of the profession occupied a few years ago. It is certainly true that, where millions of dollars are spent on engineering projects, some money should be devoted to securing accurate surveying and mapping data. In the past many projects have been constructed in places which were not suitable for them, and as a result much money has been lost to investors. With an accurate map, the consultant engineer can advise a client as to whether or not a project can be successfully carried out in a certain locality.

Not only are surveying and mapping valuable in construction work but they are of the utmost importance to the owners of property. The topographic mapping gives a complete knowledge of the lay of the land, or what is generally called the terrain. If the owner wishes to sell his property, he need not take the prospective purchaser to see it. He can show him the location of the land on the topographic map. The control surveys, in the form of triangulation and traverse, enable one to locate the boundaries of a piece of property, whether it is merely a town, a city lot, or a large estate. These control surveys make it possible to have the state, county, and city boundaries placed in their proper positions, and always thereafter the boundaries can be reestablished with a high degree of accuracy even if the boundary monuments have been disturbed.

Land is fixed in extent, but the population of the world is increasing rapidly. Thus there is a smaller amount of land per person as the years pass. This certainly means that land will become increasingly valuable. It means, further, that the boundaries of private and public lands must be established with a higher degree of precision. There have been many cases where excellent surveys have been of only temporary value because the engineers making them left no permanent monuments.

Many years ago my own organization, the U.S. Coast and Geodetic Survey, was negligent in this respect. Its engineers would make a hydrographic or topographic survey along a portion of the coast and think that the triangulation stations used to give these surveys accurate geographic positions would never be used again. In some cases, the triangulation stations involved were marked with wooden hubs, bottles placed under ground, or some other more or less obscure object. The result was that many of these old stations are now lost and the work must be supplemented by new triangulation. The Coast and Geodetic Survey changed its methods 30 years ago in this respect, and now all of the stations are marked in a very substantial manner, with inscribed metal tablets placed in blocks of concrete, stone, or outcropping rock. I cannot too strongly emphasize the need to perpetuate the control survey stations by means of such monuments.

William Bowie, M. Am. Soc C.E.
Chief, Division of Geodesy
U.S. Coast and Geodetic Survey

Washington, D.C.
December 30, 1931

Aerial Photographs in Topographic Surveying

To the Editor: In reading Mr. Ylvisaker's paper on "Surveys of the Upper Mississippi River," published in the December issue, I was impressed by the attention that he has given to adapting the survey to the varied requirements of the project and by the success with which the plan met those conditions. The specifications for each portion of the work were complete as to accuracy requirement, but were so correlated that, after the work had been in progress for more than three months, the area to be covered by the contour map was increased from 261 sq. miles to 972 sq. miles, without any change in

View of the Upper Mississippi River Typifying Mapping Difficulties

Mississippi River Survey—Traverse Party Starting from a Control Monument

the specifications as originally drawn, and without any loss or hardship to either the contractor or the Government.

I feel this careful planning of the work deserves special commendation. So often engineers in charge of projects give the matter of surveys little attention. Their thoughts are so hazy on the subject that, until the map is completed and put to the test of usage, there is no way of determining whether the accuracy and detail shown will completely serve their purpose or not, or whether the expenditure is advisable or inadvisable. I have long been of the opinion that any survey worth making is worth a careful study of its requirements and formulation of a complete set of specifications, setting forth the accuracy to be maintained in each of its component operations. This should be followed, during the progress of the work, by actual field tests of the accuracy of results, such as those applied on the Upper Mississippi River survey. This testing of the map should be done regardless of whether the survey is made by contract or by the engineer in charge of the project. Such tests are not expensive and will give assurance that the survey accomplished is that which was planned.

AERIAL PHOTOGRAPH AND CONTOUR MAP
Contours Obtained by Plane Table; Photographs Used to Determine Position and Shape of Drainage Lines—of Great Assistance in Shaping Contours

While this survey is described as an aerial topographic survey, it should, in order to avoid confusion, be clearly understood that the aerial photographs were used only to supply physical data such as the location of houses, roads, railroads, streams, and fence lines. These data were transferred in correct position to plane-table sheets, which were sent to the field and the contours located instrumentally by the plane-table stadia method. This procedure gave opportunity for a field check on the interpretation of the data obtained from the aerial photographs, which is a very necessary procedure where complete map accuracy is desired.

I am convinced that aerial photographs are of great assistance in topographic surveys. They speed up the work, reduce the cost, and increase the accuracy of detail. They also often make for better topographic expression. The fact that the survey was accomplished at a contract price of $153.35 per mile and carried on through the winter, when the thermometer did not get above zero for a week at a time, is evidence of the assistance rendered by aerial photography.

W. N. BROWN, M. Am. Soc. C.E.
W. N. Brown, Incorporated

Washington, D.C.
January 7, 1932

Township Boundaries Defined by Congress

DEAR SIR: In his article, "Recovering and Identifying Original Government Section Corners," published in the December issue of CIVIL ENGINEERING, J. S. Dodds states that "it was the original intention to make the townships six miles square."

The *Manual of Public Land Surveying* says that, according to the original act, the townships were "seven miles square, containing forty-nine sections of six hundred and forty acres each."

Later this act was amended to read "six miles square," but no further change was made for some time. Thus Congress was authority for the statement that 6 squared equals 49.

C. D. PURDON, M. Am. Soc. C.E.

St. Louis, Mo.
January 5, 1932

Diatomaceous Silica Not an Injurious Adulterant

TO THE EDITOR: The article by Mr. Nicholson, "Protecting Reinforced Concrete Against Deterioration by Sea Water," in the November issue, is very interesting and the data and information given will unquestionably be of value to engineers having to deal with the waterproofing of concrete marine structures. However, the paragraph on page 1245, giving Professor Abrams' conclusions on the use of admixtures, calls for some comment. When taken as the last word regarding the merits of some admixtures, the conclusions are, to say the least, unfavorable. In my discussion of Professor Abrams' original paper, in which I used the data given there, my conclusion was that Celite or diatomaceous silica as an admixture can hardly be classed as an "injurious adulterant."

My discussion also brings out the fact that the "flow" and the "slump" are not criteria as to the workability of the concrete when changes are made in the characteristics of the concrete by varying the proportions, by varying the aggregate or the brand of cement used, or by the addition of an admixture. These two conditions are essentially indicative of the wetness or relative fluidity of the concrete and cannot show the inherent characteristics of the mix that have an effect on the workability. The use of additional cement is universally recognized as being desirable from a workability standpoint. For concretes gaged to the same slump, or flow, the richer mix is universally recognized as being the more workable. The differences between the concretes, except as they are brought about by varying the water in a given mix, cannot be brought out by the flow or the slump tests.

The action of Celite as an admixture is essentially to improve the workability of the concrete. In promoting this property in concrete mixtures, it insures a more

nearly uniform distribution of the ingredients. That it accomplishes this purpose was shown in studies of the effects of admixtures on segregation of concrete made by G. M. Williams, M. Am. Soc. C.E., Professor of Civil Engineering at the University of Saskatchewan, and published in the *Journal of the American Concrete Institute*, February 1931. By maintaining the integrity of the concrete, a more homogeneous and satisfactory structure is obtained than would otherwise result. It is only in this regard that powdered admixtures of the non-water-repellent type are beneficial in promoting water-tightness of concrete structures.

Where it is necessary to prevent even small amounts of water from entering concrete, as in marine structures, there are only two possible methods to pursue. They are, as Mr. Nicholson indicates, membranous coatings and impregnation. No matter how good a concrete may be, it is porous and will take up an appreciable quantity of water, though it is impermeable from the standpoint of actually permitting water to pass through it. In order to prevent the ingress of the smallest quantity of water, it is necessary to seal the concrete after it is cured to close all pores and prevent the cement gel from absorbing the injurious salt-bearing water.

G. A. Smith
Concrete Research Engineer
Johns-Manville Corporation

New York, N.Y.
January 2, 1932

Soil Mechanics and Geology

Dear Sir: The subject of the use of engineering principles in earthwork construction, treated by Mr. Lee in the August issue, is an important one.

The cooperation of a geologist in important engineering structures immediately connected with earth is highly desirable and often indispensable; but a boundary line should be established between the fields of soil mechanics and engineering geology. Although these two sciences are very close to each other, the two terms stand for somewhat different methods of approach.

As I understand it, soil mechanics is an applied engineering science, studying the general theory and, to a certain extent, methods of design of earth structures or parts of other structures in connection with soil. Homogeneous soil masses or simple and quite definite cases of stratification are considered. Soil mechanics makes wide use of mathematics; to it the subjects of engineering mechanics and soil physics are also permanently linked. Students of soil mechanics have not been satisfied with field observation only, but have made wide studies of soil phenomena in the laboratory, generally using fairly homogeneous samples. Engineering geology represents a short outline of the general geological knowledge necessary for a civil engineer and a study from the geological point of view of certain special engineering problems, such as tunnels, landslides, and dams. Obviously, there are no perfectly homogeneous soil masses in nature, and in each serious case a geological reconnaissance should be made and the geological features of the locality established. After that, it should be decided which theory of soil mechanics may be used in a particular case and to what extent it may be applied. The civil engineer should be able to prepare the geological profile either by himself, or with the help of a geologist. In complicated cases the duty of the engineer consists in formulating a sound and practical set of questions to which adequate answers may be expected from the geologist.

As a rule, soil mechanics and engineering geology have been developed separately. There are even textbooks on engineering geology in which little or nothing is said on the subject of soil mechanics. It is difficult to predict whether these twin sciences will develop separately or will form a single scientific body; the path of development may possibly depend on the personalities of future investigators. An effort on the part of German geologists and civil engineers to unite both sciences should be mentioned. This is a book on engineering geology (Redlich, Terzaghi, and Kampe, *Ingenieurgeologie*, Berlin, 1929).

It should be added that the cooperation of the engineer and the geologist may take place not only in engineering, but in geology itself. This is true in the case of structural geology where the action of forces on the earth's crust is considered, which, generally speaking, is the field of engineering mechanics. However, the geologist, or his advising civil engineer, who applies theories relative to the strength of materials should be very careful. Many of these theories are valid only within the elastic limit, and a great many deformations in the earth's crust are plastic. A very interesting example of the application of the theories of plastic flow to geology may be found in Nádai's book, *Plasticity, A Mechanics of the Plastic State of Matter* (New York, 1931). In this work, shearing phenomena in rocks, pressure in the earth's interior, mountain building, and isostasy are discussed from the standpoint of advanced physical and engineering theories.

D. P. Krynine, M. Am. Soc. C.E.
Research Associate in Soil Mechanics
Yale University

New Haven, Conn.
December 28, 1931

A Fair Basis for Taxation

Dear Sir: I do not agree with Mr. Grunsky that "The Way to National Progress and Prosperity" is through taxation, nor even that taxation should be based on ability to pay, as he has set forth in his article in the October issue. The correct basis for taxation is the value of the protective service rendered by the state. Progress and prosperity are most pronounced in those states which render all necessary protective service with least cost to the property or individual taxed, and which permit the free accumulation of great wealth for development of the resources and commerce of the state. Without great wealth there can be neither property nor income of magnitude to be taxed. Without tax income no state can give ample protection.

Furthermore, the state does not owe all desirable comforts to its citizens. The protective service which we have come to regard as a duty of the state includes: Police protection in all its various forms against the exploitation of the weak by the strong; protection against disease; protection against restraint of movement of person or property; and, in a country with universal suffrage, protection against ignorance.

None of these duties warrants the state in providing desirable facilities for the advancement of some portion of its population at the expense of the remainder of it. Free common school education for all the people is necessary to the very existence of the state where there is universal suffrage, but the state is not justified in furnishing the higher education free. It is admitted that taxation is unevenly distributed. What the taxing authori-

ties endeavor to do is to levy the tax so as to procure a maximum return—probably 90 per cent of the personal property held by individuals escapes taxation, and will always escape because of the freedom of movement of such property. To abandon taxation of real property will defeat one of the duties of the state—protection of the weak against exploitation—because the masses of real estate holders will lose all interest in the amount of the taxes collected. The vicious feature of income taxes as they are now levied is the exemption of all incomes below certain arbitrary amounts. If the exemption were fixed solely on the basis of net return to the state—that is, the amount received above the cost of collection—instead of ability to pay on the part of the citizen, which would make most of the public income-tax payers, those who pay would exhibit as much effective interest in the levying of the income tax and in the expenditure of the proceeds as is now manifested by the real estate owners.

The spiritual and cultural advancement of the past, which is of the greatest importance to those now living, was accomplished without such external aids as are suggested in "The Way to National Progress and Prosperity." That advancement was the result of inspiration on the part of a few, who had the leisure to entertain, develop, and broadcast their thoughts to and through disciples.

J. E. WILLOUGHBY, M. Am. Soc. C.E.
Chief Engineer, Atlantic Coast Line Railroad Company

Wilmington, N.C.
December 21, 1931

Need for Handbook on Welding

DEAR SIR: There have been some replies to my letter, in the June issue of CIVIL ENGINEERING, relative to welded connections in beam and column structures. However, there is still lacking complete evidence in support of this type of construction—a type that has many important factors in its favor. I should like to ask further questions on the subject in the hope that additional information may possibly be forthcoming.

If all beam and column connections can be so welded as to develop the full bending strength of the beams, we can obtain a stronger structure and do it with less steel than is required in riveted work. Except in the simplest arrangement of beams, can such connections be made? When a beam is placed close beneath the flange of the girder to which it is framed, can a welded connection be made that will develop the full bending strength of the beam? If so, how? When a girder is of less depth than the beams it carries, what form of connection is made? If the girder beams with wide flanges frame into opposite flanges of a light column and smaller beams frame slightly higher into the column web, is there a practical means of making connections of full bending strength?

Two large beams of adjacent spans are framed with their webs flat against the opposite flanges of a light column, the web of which is perpendicular to the direction of beams. If solidly welded, the deflection of beams will throw a reverse curve into the column web in one direction at beam tops and in the opposite direction at beam bottoms—a distortion of web of about $^1/_8$ in. at each point for 20-ft. beam spans. Riveted joints are accepted for such work. Could such an arrangement of beams be connected safely by welding?

When the designer tries to apply welding in such cases as these, he is confronted with the difficulty of so arranging his details that the rigidity of the framework will not cause unexpected weaknesses in the main members themselves. Regarding the necessity of designing for rigid connections when solid welding is to be employed, the following simple example illustrates the contrast between the designs for riveted and welded work. A single line of beams is supported by light columns or by girders which do not fix the ends of beams. The spans are alternately 30 ft. and 11 ft. The load is 3,000 lb. per lin. ft.

For the simple beams of riveted work the bending in the long span is 337,500 ft-lb., requiring a 26-in. I-beam weighing 91 lb., while that in the short span is 45,400 ft-lb., requiring a 12-in. I-beam weighing 25 lb.

If this design is unwisely used to make solid welded end connections, the moments in the resulting continuous beam differ widely from those calculated. The negative bending, in the ends of both beams, is 82,100 ft-lb., which is far too much for the smaller beam. The positive bending in the larger beam is 255,400 ft-lb., and the negative bending at the center of the smaller beam is 36,700 ft-lb. A single size of beam is required for the two spans. This is a 22-in. I-beam weighing 58 lb. Welding affords a 23 per cent saving in steel, allowing for standard connections. This is a matter well worth consideration, but there is the danger that the beams will be designed as simple spans and then welded, thereby creating an unsafe stress of 32,000 lb. per sq. in. in the end of the small beam.

It seems only fair to suggest that the firms manufacturing welding equipment and promoting this type of construction could advance the art more rapidly if they would supply us with a handbook showing the possibilities and limitations of welding and giving helpful hints for the design of welded frameworks.

LEONARD C. JORDAN, M. AM. SOC. C.E.
Consulting and Designing Engineer

New Rochelle, N.Y.
December 15, 1931

Pre-Stressing Welded Steel Increases Capacity

TO THE EDITOR: In connection with the articles and discussions on welding in CIVIL ENGINEERING, I should like to submit the following comments on the subject, made by the late Peter Gillespie, Professor of Civil Engineering in the University of Toronto, and found among his papers.

"While the advantages of continuity in beams have long been recognized, and while the pre-stressing of steel in structures is scarcely a new art, structural welding is of comparatively recent development. Is it possible to combine the processes of welding and pre-stressing so that the advantages of continuity may be realized?

"Suppose that the safe load, uniformly distributed on a freely supported steel beam is W, and the permissible flexural stress, f. Let the beam be supported on shelf angles attached to rigid metallic supports and let a load of $\frac{W}{3}$ be applied at midspan. This will produce a center bending moment of $\frac{Wl}{12}$ and end slopes in the elastic line of $\frac{Wl^2}{48EI}$. In this deflected position, let the ends be welded to the supports, after which the center load is released leaving a positive bending moment, constant in magnitude from end to end, equal to $\frac{Wl}{24}$. To this beam a uniformly

distributed load of $2W$ may then be applied, in which case the center and end bending moments will be $+\frac{Wl}{8}$ and $-\frac{Wl}{8}$ respectively. In other words, without exceeding the permissible stress, f, the carrying capacity of the beam has been doubled.

"If f is 16,000 lb. per sq. in., the safe load, uniformly distributed for an 8-in., 17.5-lb. I-beam 12 ft. long and freely supported, is 13,000 lb. A center load of one-third of this will produce a deflection of 0.15 in. and end slopes of 0.0032, equivalent to $\frac{1}{40}$ in. in an 8-in. height. While the beam is in the bent state, the ends are welded to rigid supports, after which the straining load is released. In this condition a load of 26,000 lb., uniformly distributed, will produce flange stresses at center and supports of 16,000 lb. per sq. in., points of contra-flexure being distant $0.15\ l$ from either extremity.

"With flexible supports and beams in series, the problem theoretically and practically becomes enormously involved. Notwithstanding this fact, are there any possibilities in it for usefulness in the rapidly developing field of structural welding?"

C. R. Young, M. Am. Soc. C.E.
Professor of Civil Engineering
University of Toronto

Toronto, Canada
January 4, 1932

More Filter Studies Needed

To the Editor: In their paper on "Trickling Filter Loading," in the December issue, Messrs. Childs and Schroepfer have presented in a clear and concise manner certain data and information which should be of considerable interest to the sanitary engineering profession—particularly the engineer engaged in the design of sewage treatment works. Trickling filters and other sewage-treatment units have been designed and constructed in the past despite very limited information as to the degree of efficiency of sewage treatment which may be expected under various anticipated operating conditions. It is through such data and the information presented in this paper that we will be able to determine more exactly the factors of safety in sanitary engineering practice. It is to be hoped that supplementary material similarly correlated with operating factors will be made available at other sewage treatment plants throughout the country.

In the presentation of the subject the authors have confined themselves to a study of the effect on filter efficiencies of sewage strength and rates of application. In view of the fact that the many other features of filter construction and operation have been disregarded, a review of the data correlated and presented in charts cannot help but impress one with the rather remarkable "flexibility" of a trickling filter. Particularly is this true when it is considered that the 15 plants included in the study present a wide diversity of local conditions as well as design features.

In the study of the filter efficiencies the bio-chemical oxygen demand tests have been the only measuring stick used. The results indicate that the efficiency of a given trickling filter is not, within reasonable limits, influenced materially by a rather wide variation in the strength of sewage or rate of application, and the strength in terms of oxygen demand of the treated effluent is directly proportional to the strength of the filter influent. It is further pointed out, however, that there must obviously be a loading beyond which the efficiency will be reduced, and the determination of this loading along with other controlling factors is of much importance to sewage-works designers and operating engineers. Nitrification studies correlated with oxygen demand data would be of very material assistance in determining the limits of filter loading. It is desirable, therefore, that more attention be given to equipping sewage-plant laboratories with facilities for the determination of nitrogen in its various forms—particularly nitrates and nitrites—in connection with trickling filter efficiency studies.

Trickling filters have received a considerable amount of attention in recent years in connection with the treatment of various trade wastes. With certain types of these industrial wastes—particularly those most nearly approaching domestic sewage in nature—trickling filters have been found to afford the most practical and effective means of treatment. Published data and information on the economical design of trickling filters to take care of these particular wastes under different operating conditions are very limited. Unquestionably more studies like that of Messrs. Childs and Schroepfer are needed.

The relation applying to sewage filters has been found to hold true, within limits, in experimental studies of the treatment of milk plant wastes at DeForest, Wis. It was found, however, that continuous heavy loading of the trickling filters with the strong milk wastes, such as whey and buttermilk, resulted in ponding difficulties. The filters, according to the data available, are able to take care of considerable increases in loading for short periods of time with but little, if any, decrease in treatment efficiency as measured by reduction in the five-day bio-chemical oxygen demand. From the nitrification point of view, however, efficiencies appear to decrease materially with increased filter loadings. More information on this phase of filter operation will be necessary to justify a statement on the relationship between the degree of nitrification and filter loadings.

L. F. Warrick
State Sanitary Engineer
Wisconsin State Board of Health

Madison, Wis.
December 7, 1931

Loading and Efficiency of Trickling Filters

To the Editor: In their article on the effect of loading on the efficiency of trickling filters, in the December issue of Civil Engineering, Messrs. Childs and Schroepfer have presented interesting data. As they have pointed out, however, these data are rather meager for the purpose of drawing conclusions. If more figures were available for each of the plants studied, covering a greater length of time and a wider range of loadings, it is logical to expect that, beyond a certain point for each filter, increased loading would be found to cause a decrease in efficiency. It seems to me that even the data presented by the authors indicate a decrease in efficiency with increased B.O.D. (bio-chemical oxygen demand) loads for some of the plants studied.

In order to bring out more clearly the facts in relation to some of these plants, I have used figures furnished by the authors to plot curves showing the relation between filter loading and percentage reduction in 5-day B.O.D. The curve drawn for Decatur, Ill., indicates an increase in filter efficiency with increasing B.O.D. loads up to approximately 0.11 lb. per sq. ft. daily, beyond which the

efficiency decreases. The curve for the Burke plant at Madison, Wis., when treating packing-plant wastes, has a similar shape, with maximum efficiency at a loading of approximately 0.22 lb. per sq. ft. daily. For the Burke plant, when domestic sewage alone is treated, the curve indicates that the filter efficiency decreases rapidly with increasing B.O.D. loads, although the range of loads applied to this filter was extremely limited.

While the oxygen-demand test furnishes valuable information upon the oxidation of sewage, the test is subject to so much uncertainty and has been in use for such a relatively short time that the data supplied by it are perhaps not as valuable as those furnished by some other tests for determining the relation between the filter loading and the efficiency of any particular filter. In order to derive the most conclusive evidence from such a study, it probably should be based on annual averages of regular and frequent analyses, to eliminate errors due to fluctuations in temperature and in character of sewage treated. Such a study, extending over a long period of years, is possible only if one of the older determinations—such as free ammonia, nitrites, nitrates, or oxygen consumed—is utilized. In this connection it should be mentioned that the nitrification of ammonia appears to be a more delicate test of the performance of a filter than the reduction of oxygen demand.

Another point to be considered in such a study is the quality of effluent produced, not only relative to the influent but in an absolute sense. For example, let it be assumed that a given trickling filter is operated, during eight out of ten years, in such a way as to produce an effluent of a uniform quality and that during the other two years the effluent is of a distinctly higher quality. The reason for the improvement in one year may be an increase in efficiency with more or less the same loading, while in the other year it may be a smaller loading even with a decrease in efficiency. Therefore, it would appear that the most valuable comparison of performance is to be derived from a consideration of the effect of loading on efficiency during the years when an effluent of uniform quality is produced. This is especially true because sound economy requires, in so far as is practicable, that trickling filters be designed to produce effluents of a certain necessary range of qualities, in order to meet the needs of the natural waters into which the treated sewages are to be discharged.

In order to determine the effect of various filter loadings on the efficiency of a trickling filter over a long period of years, the reports of the Massachussetts Department of Public Health, concerning the work of the Lawrence Experiment Station, have been consulted. Filter No. 135 at this station has been in operation since 1899, and during all these years it has produced an effluent of reasonably uniform quality, if judged by annual averages of nitrites, nitrates, free ammonia, and oxygen consumed. The filter consists of walnut-size stone, 10 ft. in depth, and is dosed with sewage from the Lawrence sewerage system.

A study of the efficiency of Filter No. 135 under various loadings indicates that, if a trickling filter is operated for a number of years in such a way as to produce an effluent of substantially uniform quality, its efficiency, as measured by the reduction of free ammonia, increases up to a certain point with increased loading. However, when the load is increased beyond that point, its efficiency decreases.

HARRISON P. EDDY, M. Am. Soc. C.E.
Consulting Engineer

Boston, Mass.
December 17, 1931

Recalling the Choosing of Homestake Pass

DEAR SIR: I enjoyed reading Mr. McHenry's story of the Homestake Pass, on page 1301 of the November issue. There are several reasons why I recall work on that line. In March 1889, I worked first on preliminary surveys of the Pipestone Pass; and after the Homestake route was chosen I was engaged on the work of location and construction, finally serving as resident engineer and finishing up the work, which was about completed in 1890.

Before the route of the Northern Pacific had been definitely decided upon, there was considerable controversy between the cities of Butte and Helena as to the best crossing of the Rocky Mountains. Finally the Helena route into the Mullan Pass was chosen, and the line was built that way.

McHenry's account of the choice of the Homestake Pass is modestly written, but I well remember that it was his genius in analyzing the surveys that had been made that led him to suggest a resurvey of the Pipestone Pass. The business men of Butte were very much aroused by this suggestion and employed a competent locating engineer to make an actual preliminary survey. McHenry put two seasoned locating engineers at work on the survey of the Pipestone Pass and a rather young and inexperienced man on the Homestake Pass, for while the Pipestone Pass had been discussed for some years, even the existence of the Homestake route had never been suspected.

I was draftsman for the party and worked on the west side of the Pipestone location. We had finished the preliminary survey and I was inking in the Pipestone profile I had just made when J. W. Kendrick, Chief Engineer of the Northern Pacific, and McHenry came into our tent. They had the profile of the Homestake preliminary survey and wished to compare it with the Pipestone profile which I was actually inking. I kept them waiting perhaps five or ten minutes before they were able to place these two profiles alongside each other and observe them.

This was the first time that anyone had ever compared a Homestake profile with a Pipestone profile. Kendrick and McHenry with the rest of us looked at these profiles for several minutes without saying a word. Then McHenry broke the silence with, "Well, Kendrick, what do you think of her?" Kendrick replied, "Pretty good." McHenry said, "She's a dandy. Is there any question in your mind as to which is the better line?" Kendrick replied, "None in my mind, but we will wait until we get the comparative estimate." Fifteen months after this comparison of the two profiles the first passenger train ran over the Homestake Pass; and fifteen years later the Milwaukee built its road over the Pipestone Pass, which the Northern Pacific in April 1889 had abandoned for the Homestake.

When Kendrick met the people of Butte he thanked them for their interest in the project and said that while studying the Pipestone Pass his engineers had found a better route and the line would be built over the Homestake Pass. This was of course very satisfactory to the citizens of Butte.

In the early days the Homestake Pass was rather weird and terrifying. With marvelous luck in the use of barometers and remarkable judgment in estimating distances, McHenry established a point about 17 miles from the summit of the pass and set a stake to indicate his estimate for the foot of the supported grade from the

summit. This was within 2,000 ft. of the line that was afterward constructed. There were $3^{1}/_{2}$ miles of timber bridges in about 20 miles of mountain construction. These trestles were largely on 10 to 12-deg. curves and ran from 100 to 140 ft. high. These were replaced 13 years later, so we saw the $3^{1}/_{2}$ miles of wooden bridges become 1,800 ft. of steel.

For the rock cuts McHenry selected a quarter to one slope which looked steep at the time. But, looking backward, I am more and more impressed with his nerve and sound judgment, and this respect is based on six years as superintendent of the Montana Division which included the line over the Homestake Pass. Had a flatter slope been used in this disintegrated granite, the slides would have been heavy and expensive to say nothing of the very heavy increase in the construction cost.

There is some correspondence in McHenry's files between him and the then Chief Engineer of the Northern Pacific, which brings out what might be called the ultimate possibilities of the Homestake Pass. It might be a one per cent line with a tunnel from five to six miles long. The actual accomplishment of this goal may take a long time, but it is comforting to know that the undiscovered Homestake is so good.

Henry J. Horn

Brookline, Mass.
December 30, 1931

Progress on the New York Regional Plan

To the Editor: It may be of value to make a comparison between the Chicago Regional Plan, as described by Mr. Kingery in the December issue, and New York's regional plan. It was fortunate that two of the men who were most active in the preparation of the plan of Chicago were also at the head of this plan. These were the late Charles D. Norton and Frederic A. Delano, chairman and secretary, respectively, of the Commercial Club Committee under whose direction the Chicago Plan was prepared. At Mr. Norton's untimely death in 1923, Mr. Delano assumed the chairmanship of the Committee of a Regional Plan of New York and Its Environs.

Both plans were financed from private funds, which allowed them a freedom of expression which might have been impossible in an official commission. In some respects the problems in New York have been more difficult than those in the Chicago region. The Chicago area was more homogeneous than New York, where there has been, and still is, considerable rivalry between the New York and New Jersey sides of the port. Cooperation of official agencies was for that reason more difficult to achieve in New York.

The procedure in developing the New York Regional Plan has involved the following lines of activity, which have overlapped in schedule: (1) a comprehensive survey of the region; (2) an educational campaign to arouse a demand for better planning; (3) formulation of the regional plan itself as a guide for future growth; and (4) promotion work for the regional plan coupled with continued education of the public.

To date this procedure has been followed for ten years. The length of this period in itself indicates that the studies have been deliberate and that the conclusions reached have not been hasty. They have been subjected to such research as would take place in a well organized laboratory.

The first publication work to be undertaken was that of the *Regional Survey*, but publication of the last two of the eight volumes of this survey overlapped that of the *Regional Plan*.

The first volume of the *Regional Plan*, dealing with communication facilities and land uses, was published in 1929. The second volume, on the building of the city, or its vertical growth, has just appeared. Upon the publication of the first volume a Regional Plan Association, somewhat similar to that in existence in Chicago, was created. This is an incorporated body, which has taken over the promotional, publicity, and educational end of the activities and is raising its own funds by popular subscription. The educational work, however, had already been started in 1922 following the first public announcement of the regional plan activities.

The New York plan embraces an area of about 5,500 sq. miles, which contains not only the greatest concentration of population in the world but also a large percentage of undeveloped areas with ranges of hills reaching a maximum height of 1,600 ft. The plan is based on a diagrammatic scheme for communication and a region-wide system of existing and proposed land uses. All these proposals have been carefully coordinated in a single map called the Graphic Regional Plan.

The second volume of the *Regional Plan* discusses the art of city building and presents principles and proposals dealing with the subdivision of land, zoning, housing, improvement of terminal facilities, and the fitting of streets to the buildings. It also includes all the architectural studies made in connection with the plan and presents specific proposals showing how the outstanding opportunities of the region can be realized.

Publication of the greater part of the *Regional Survey* in advance of the *Regional Plan* did much to stimulate planning activities. A regional consciousness was developed, and the results of the researches printed in the survey were put to practical use. Although the last half of the plan has only recently become available in printed form, much progress can already be reported as a result of the activities of the committee and the Regional Plan Association. These include the following: (1) introduction and passage of state legislation to facilitate better official planning; (2) creation of many new official planning commissions; (3) organization of local county committees to promote local planning and to cooperate with the Regional Plan Association; (4) holding of public district meetings at which important proposals, contained in both the *Regional Survey* and the *Regional Plan*, and affecting the particular district, have been presented and explained; (5) continual collection of data in regard to public and private projects related to the plan; and (6) adjustment of the plan where needed to keep it alive and up to date.

Harold M. Lewis, M. Am. Soc. C.E.
Consulting Engineer

New York, N.Y.
December 9, 1931

Developing a Regional Plan Difficult

To the Editor: The interesting article by Mr. Kingery on "Executing Chicago's Regional Plan," in the December issue, shows the necessity and value of continuous and persistent pursuit of the main objectives of a regional plan until those objectives are actually secured. No plan can accomplish itself.

The importance of adherence to route locations and standards of width and clearances is rarely visualized clearly by the suburban cities and villages in a metro-

politan area. Hence creation of building obstacles cannot be entirely prevented. Even a large city with a paramount interest in the working out of plans designed to effect great future economies in the expansion of its traffic and transportation facilities may find it difficult at times to resist influences within its own limits that are not in sympathy with the plan.

As early as 1807 Detroit had a master plan, designed under the direction of the governor and judges of the territory, which plan, if continued, would have satisfied all the traffic and transportation requirements of the present day. However it lasted only nine years.

In 1830 Governor Cass completed five military roads, 100 ft. wide, originally ordered by the War Department in 1913. These roads, connecting Detroit with Lake Erie at Toledo, with Fort Dearborn on the site of Chicago, with the mouth of Grand River on Lake Michigan, with Fort Saginaw at Saginaw Bay, and with Fort Gratiot at Lake Huron, effectually assured the commercial future as well as the military accessibility of the city. The right-of-way of Government roads should not require watching, yet Detroit now finds itself obliged to pay approximately $35,000,000 to recover right-of-way lost by encroachment on these roads within its present corporate limits.

The present regional plan for the Detroit area is about 40 per cent accomplished so far as the acquisition of right-of-way is concerned. In accordance with specifications, 100 miles of new pavement have been laid on superhighways, and structures have been built at typical points that make plain the advantages to traffic and the construction economies to transportation that will be realized if the objectives are carried out. If Detroit is fortunate enough to see this plan completed, it will be by means of the same unrelenting effort, diplomacy, and skill that characterized the work of the Chicago Regional Plan Commission.

The predetermined development of a skeleton of trunkline routes for traffic and transportation is of great assistance in the provision of other basic necessities. It makes available direct routes for water supply mains and trunk sewers. It offers an opportunity for development of a comprehensive plan for reduction in the number of railroad grade separations and for delimiting and conserving industrial territory. It frees the property in developed areas bounded by main thoroughfares from the menace of future disturbance and offers the widest latitude to individual development in new areas along lines of permanence. In these respects the regional plan is an automatic zoning regulator. It provides, in a word, for the orderly guidance of the growth of cities in lieu of the disorderly, haphazard, and wasteful evolution by force of circumstance that takes place in the absence of a regional plan.

JOHN P. HALLIHAN, M. Am. Soc. C.E.
Chief Engineer, Rapid Transit Commission, Detroit

Detroit, Mich.
December 15, 1931

Unique Leveling Method

DEAR SIR: Recent articles on irrigation and hydraulics in CIVIL ENGINEERING, call to mind some phases of similar projects in the Old World. These have been forcibly drawn to my attention during a study of engineering structures in Transcaucasia.

The Soviet Union is full of unusual things, among them what may be the oldest irrigation canal in the world. It diverts water from the Arax River in the vicinity of Erivan, Armenia. According to a stele in cuneiform, it was built about 900 B.C. The stele tells of its construction by a certain king or chief and then proceeds to call down a curse on anyone who destroys either the stele or the canal. It seems to have been effective as a means of protection, as the canal is still in operation, although the stele has been cracked by an earthquake.

The Armenians have also a unique method of canal location called "goat leveling." They have discovered that a goat will neither go uphill nor downhill unless he has to. When they wish to build a canal, they take a goat to the vicinity of the proposed intake and turn him loose in the right direction. The goat traverses the contour and they peg down after the goat. It is a simple and satisfactory means of securing the grade since if the canal does not work they can blame it on the goat. Wise old Armenians! It is a pity we cannot employ a goat on more complicated structures.

CHARLES R. OLBERG, M. Am. Soc. C.E.

Tiflis, Transcaucasia, U.S.S.R.
December 23, 1931

The Engineer in a Business Capacity

TO THE EDITOR: Various interesting aspects of the present economic situation are suggested by Mr. McDonald's paper on "The New Competition and New Horizons in Engineering," in the December issue. Group action and mass production are common, everyday terms now being suggested for improving the economics of farming, which has long been the outstanding industry of individual effort.

In his article, Mr. McDonald tells us that the individual in engineering practice is threatened with the over-all practice of industrial agencies in many lines, and that it is up to the engineer to find new fields to attach to his present practice, so as to resist and overcome the invasion.

Although the engineer is usually considered a professional rather than a business man, there are numerous outstanding examples of his handling business enterprises successfully. One of the largest, if not the largest, industrial business in the United States has been successfully managed by a professional man—a lawyer. Likewise, many of our greatest railway systems are headed by professional men—engineers.

These men possess executive ability as well as legal or engineering talent. In a consideration of the present and future position of the engineer in the economic field, this points to the fact that, unless the individual is outstandingly ahead of his fellow workers in technic, he must develop other latent abilities and put them to use in, perhaps, a commercial way. In other words, it will not be enough for an engineer to report that an engineering project is safe and can be produced for a stated cost, but he must be able to go farther and answer the question as to whether it will pay and also, perhaps, arrange for the financial program. Mr. McDonald considers this program the climax of the well rounded engineering career to meet the new competition; and why not?

Let me illustrate by an example in my own experience. A man came into our office several years ago, with plans for a hydro-electric plant. He owned the site for a dam and had a prospective contract for the sale of his power, but he had to bond the project and had not succeeded in this phase of the project. The proposed contract provided for the payment by the power company to the

owner of 6 mills per kw. for prime power. Knowing the flow characteristics of the river, we advised him to get the contract changed to 5 mills per kw. for all the power of the full flow of the river. Then we took the bonds and sold them, which represented a practially complete service to the client.

Prior to October 1929 there were many business executives and bankers to whom all looked for leadership, but since then we have found many instances of sad inability in those who were formerly leaders. We are still too reliant on the stock market. Our system of credits has failed utterly to provide for general business, and we are in a slough of despondency. Have the business man and the banker presented a solution for the present economic crisis?

It is stated that this is a machine age developed by the engineer and that by some legerdemain he should now cause vast consumption of products. The economic problem of business, of banking, of construction, and of engineering is a most vital one. Perhaps, however, it represents an opportunity, in connection with other agencies, to broaden our field of engineering endeavor, and help reach a solution for the extraordinary condition in which we find ourselves today.

A. J. Hammond, M. Am. Soc. C.E.
Consulting Engineer

Chicago, Ill.
December 24, 1931

Difficulties in Latin America

To the Editor: The general principle underlying Dr. Waddell's proposal for a Latin-American syndicate, outlined in the November issue, is entitled to the endorsement of American engineers, manufacturers, and bankers. New markets for our products, new sources of profit for our business, new foundations for our prestige, and many other benefits might logically be expected to result from the operation of such an organization.

The fundamental conception of the plan as outlined appears to be highly commendable. However, constructive measures result not so much from stating the benefits to be derived from a proposed procedure as from forecasting possible pitfalls and planning methods of avoiding them. With this in mind, a critical examination of possible operating problems gives rise to several questions which doubtless would require satisfactory answers before the proposed organization could become effectively operative.

For present purposes, assume a syndicate embracing the personnel suggested by Dr. Waddell—that is, 15 engineers, 30 or 40 contractors, and say 10 banking units. Then certain questions arise concerning the first project to be undertaken under the auspices of this syndicate. Which engineer or what group of engineers out of the 15 engineer members of the syndicate would handle the work and secure the commission accruing therefrom? Which banking unit or what group of such units would handle the financing of the project? Which contractor or what contractors out of the 30 or 40 contractor members of the syndicate would construct the project?

Assume that a few projects have proved acceptable and that some of the groups of engineers, bankers, and contractors have handled, or are in the process of handling, profitable operations. Meanwhile the remaining members must await the development of some project which they hope will offer opportunities for them. In connection with this situation other questions arise.

During the period of waiting for assignments, what assurance have the waiting members of the syndicate that projects of a type in which they are interested will materialize? How would selection between two members of the syndicate equally fitted to handle a project be made? What assurance could be given a member that he would ever participate in the operation of a project? What incentive would there be for any member to continue to bear his share of promotional, educational, and operating expenses while other members secured the commissions and contracts accruing from projects already under construction?

Suppose that the first few operations were finished before all of the members secured commissions or contracts and that these completed operations proved to be so unprofitable as to cause a dissolution of the syndicate. How would those members who had failed to secure commissions or appointments be reimbursed for expenses incurred through or because of the syndicate? How would a loss accruing from operations be provided for?

Generally speaking, it would appear that the reasons prompting any organization to enter the syndicate would be based upon sound business principles. The members of the syndicate would expect to secure profitable commissions or contracts, which they could not otherwise obtain. It is inconceivable that the syndicate as a whole should expect to share in the profits made by any particular member in a specific operation. The most that it could demand would be fees that each member, who received a commission or contract, would include in his contract price for the work.. The profits thus derived might be sufficient to yield a moderate return to the members upon the amounts they had invested in the syndicate, but it appears highly improbable that membership in it could be justified if the returns accruing therefrom were to be limited to such amounts.

H. G. Hunter, M. Am. Soc. C.E.
Chief Engineer, Atlantic Bridge Company

Greensboro, N.C.
January 2, 1932

Syndicate Offers Possibilities

To the Editor: To his long-sustained, brilliant record of American and foreign engineering design and construction, Dr. Waddell now adds, in your November issue, a professional and patriotic conception of great practical and technical importance in his proposal for the initiation of "A Latin-American Engineering and Construction Enterprise."

It is my belief and hope that his proposition will receive immediate and hearty support in this country and in Latin America. It unquestionably offers a sound and, at the same time, forceful campaign for the extension of activities, and for the use of capital, experience, brains, labor, and equipment needed to absorb the present surplus in this country, enlarge business and professional horizons, and build foundations for the future.

The plan would be especially opportune in these days of general depression and unemployment, which would be relieved by the proposed foreign extensions. Our great resources, now largely inert, would enable us to extend long-term credit on sound investments that would put us in favored competition with the nations that have in former years catered most successfully to local conditions in Latin America. This is a golden opportunity to establish ourselves with mutual advantage to our neighbors and ourselves.

It should be easy to demonstrate the benefits of the plan to Latin Americans in the manner suggested by Dr. Waddell. When I was in England and France in 1915, I had no difficulty in securing favorable consideration of a proposal for a survey by American specialists of the war-devastated districts. It was intended that this survey should facilitate the preparation of plans, estimates, and specifications for the restoration of highways, buildings, and public utilities especially designed to utilize local products, supplies, labor, and equipment. Although the interested agencies were at that time successfully carrying out important war contracts, they were financially ruined after my return to the United States, and I was unable to devote further effort to the subject. Had the project been undertaken, American contractors would have been able to make construction bids, based on American methods and equipment, that would have been very advantageous to the Europeans.

The international organization suggested by Dr. Waddell should appeal much more strongly than this individual effort. I would suggest that the proposed three lecturers be accompanied by a person of broad familiarity with general engineering construction, who would present to officials, heads of industries, boards of trade, and financiers illustrated lectures on the subject of American methods, equipment, and efficiency in all kinds of building and construction operations. This would demonstrate the safety, rapidity, and economy of our major construction operations.

FRANK W. SKINNER, M. Am. Soc. C.E.
Consulting Engineer

New York, N.Y.
December 31, 1931

Why Invest in South America?

TO THE EDITOR: The article on "A Latin-American Engineering and Construction Enterprise" by J. A. L. Waddell, in the November issue, possesses the merit of enterprise. However, I am moved to inquire, why go to South America when we would have little difficulty in finding a fertile field for our efforts in our own country, thereby providing employment, helping to promote better economic conditions, and, incidentally, assuring a fairer and surer compensation for work done?

I make this counter-suggestion, because it would seem wise to consider very carefully the feasibility of Dr. Waddell's proposed plan before attempting to elaborate on it, or before bringing it "to the attention of those who either are, or ought to be, interested in its materialization." Before a final determination of the merits of the idea is made, I would be interested in knowing how the following obstacles would be overcome:

First, the matter of financing arrangements is of vital importance. A development of such scope would undoubtedly involve a very substantial capital investment, and in view of the present impoverished condition of virtually all of our Latin-American neighbors, very long-term credit facilities would have to be granted. Would our great international financial institutions be receptive to any such proposition at the present time? I am of the opinion that they would not.

During recent years our bankers have poured with a lavish hand millions of dollars into South American countries. Measured by New York Stock Exchange quotations, the present value of a billion dollars worth of South American securities has dwindled to less than $300,000,000.

Discounting the abnormal factors involved, is there any reason to believe that further investments would meet with a happier fate now, or in the immediate future? Even under present conditions, a financier would probably prefer to invest in South American bonds at 30 cents on the dollar rather than to speculate at 100 cents on the dollar for a proposed new engineering and contracting enterprise.

Second, there is no dearth of American exploitation and development in South America. Such recognized corporations as American and Foreign Power, International Telephone and Telegraph, and International General Electric, together with important mining companies and numerous others in a variety of industries, all have a very substantial financial interest in Latin America. Furthermore, several American engineering and contracting corporations have already done a great deal of work in the same territory, on private account and usually on a strictly competitive basis. The recent sharp drop in the value of the pound sterling will certainly make this competition more acute for American bidders on engineering projects.

Third, and possibly the most important consideration—what will be the attitude of the South Americans to such a plan? There can be no question that they are distinctly suspicious of our motives; and however diplomatically they may be approached, they will possibly resent what they might regard as an encroachment by their neighbors of the north.

Unless the state and municipal governments in the various South American countries indicate a willingness to bury the hatchet among themselves, to cooperate more wholeheartedly, and to give some assurance that their respective governments are on a sound political basis and not subject to revolutionary upsets, it would seem at present most unwise to undertake any such adventure.

LAURENCE A. BALL, M. Am. Soc. C.E.
Ball and Snyder, Consulting Engineers

New York, N.Y.
December 11, 1931

Rivalry to Be Avoided

TO THE EDITOR: The suggestion made by Dr. Waddell in the November issue, for the economic development of South America presents features of a very large program which has been tried in a smaller way. It would seem necessary or advisable to first prepare a physical program of engineering works, so that the lecturers entrusted with the responsibility of explaining the syndicate could at the same time dwell on the benefits to be derived by the exploitation of natural resources.

As the details of the plan are already worked out, only an affirmative or negative opinion of the general plan is needed. It would seem to me, from the experience I have had in such procedures, that if a proper set-up can be made of all interested parties there is much merit in the proposal.

Perhaps one of the essentials to the success of the syndicate would be to have the firms and corporations now engaged in such enterprises join the new organization or at least express themselves favorably on the subject so that there would not develop an immediate and intense rivalry and conflict of interests.

A. J. HAMMOND, M. Am. Soc. C.E.
Consulting Engineer

Chicago, Ill.
January 4, 1932

SOCIETY AFFAIRS

Official and Semi-Official

The New President

On a July day in 1888 a young employee of the Chicago, Milwaukee, and St. Paul Railway returned to Milwaukee from a month of surveying in the pine forests of Wisconsin. He learned that a meeting of the American Society of Civil Engineers was being held there at the time. After some hesitation—because he felt that he did not belong—he decided he would attend that meeting. He wanted to see how prominent engineers behave. Dressed in his working clothes and feeling quite out of place, he did attend and resolved that some day he would become a member. The young man was named Herbert Samuel Crocker, and the memory of the meeting is still vivid in his mind. He is the newly elected President of the American Society of Civil Engineers.

HERBERT S. CROCKER
Sixty-Third President of the American Society of Civil Engineers

Colonel Crocker was born in Haverhill, N.H., on June 20, 1867. He was graduated from the University of Michigan in 1889. His early professional work was principally in the capacity of structural draftsman in the employ of several railways and bridge companies. In 1897, Mr. Crocker went to Colorado and was employed by the Denver Board of Public Works as Bridge Engineer.

The City of Denver has always been divided by the Platte River and the railroad yards which have been built on the low lands along its banks. The plan at that time was to bridge this area with a viaduct at 14th Street, thus bringing the two halves of the city together. But before the new engineer could do more than sharpen his pencils, there occurred one of those flare-ups so common in city government. When things had settled down the Board of Public Works had a new personnel, and Mr. Crocker had lost his job. But within a year he was called back by the board to build that 14th Street viaduct, the Denver City Tramway Company in the interim having hired him to inspect its bridges and to do some building and remodeling. When the viaduct was finally done, he devoted several years to remodeling and reconstructing the city's other bridges to carry the newly electrified tram cars.

In 1901, Mr. Crocker went to Chicago as Assistant Manager of Erection, Western Division of the American Bridge Company. For five years he supervised the erection of bridges in the Middle West, among them two notable ones over that unreliable river, the Missouri, one at St. Joseph, Mo., and the other at Omaha, Neb. In 1906, he returned to Denver for the Denver Tramway Company, where he spent the ten subsequent years putting more bridges over the unruly Platte and more viaducts across those sprawling railroad yards, which served to keep the city divided against itself. During a quiet interval in this work, the Denver and Rio Grande Railroad employed him to build its South Fourth Street viaduct in Salt Lake City.

It was this period of his career that served to bring out most conspicuously certain of Mr. Crocker's characteristics, his versatility and his skill at harmonizing conflicting interests. For in building these viaducts he was the focal point for sometimes as many as half a dozen potentially conflicting interests. Not only did he design and supervise for the city; he had also to hold the confidence of the tramway company and of three or four railways all at the same time. Anyone who has been in a similar position can appreciate that his success in satisfying all of the interests on all of his viaducts was no trifling accomplishment.

An earlier evidence of this same characteristic was his successful service as Engineer of the Board of Arbitrations of the Grand Crossing Grade Separation, Chicago, in 1909. In this well known arbitration case the conflicting interests of four railroads were involved, and the resolution of these conflicts brought up a number of interesting problems in engineering judgment. He is often called in to arbitrate other disputes of more or less importance.

Still another illustration of Mr. Crocker's versatility is offered by the story of those various Denver viaducts. In 1907, when plans were complete for the 23d Street Viaduct, the panic made it impossible to get steel for the job. He immediately made a substitute set of plans using timber. Again in 1914, when the Colfax-Larimer Viaduct was to be built, some doubt was cast on his fitness to design a structure of so radically different a nature. The Colfax Viaduct was to be of concrete instead of steel, and it was furthermore to be the longest viaduct of its kind in the world. All of Mr. Crocker's previous experience had been in steel. The doubters were answered, however, when his plans were accepted and the viaduct built. It stands as an excellent model of its kind.

With the coming of the war, in 1917, Mr. Crocker was appointed an associate member of the Naval Consulting Board, for Colorado. In this capacity he participated in a survey of Colorado's material resources for war purposes. When this was done, he applied for a commission in the Army, was commissioned a Major of Engineers, and reported in Washington in October 1917. It was while he was serving as Supervising Constructing Quartermaster—at the Newark Quartermaster Terminal, the Raritan River Arsenal, and the Middletown Ordinance Depot successively—that he was recommended as Constructing Quartermaster of the proposed army supply base at Brooklyn.

The construction of this base was a crucial job. At the time, Major Crocker had no reputation in building, practically all of his work having been as a bridge engineer. Yet, curiously enough, this turned out to be an important factor in his appointment. The recommendation which, perhaps more than any other, won Major Crocker this appointment says:

"He has a habit of doing work without being seasoned by experience in work of the same character; he has the faculty of sizing up a problem ahead of him and meeting the requirements; he is also characteristically competent and faithful."

In short, a job of this size, where speed was subordinate only to sound work, might be done more successfully, it was thought, by a constructing quartermaster with a wholly fresh approach to the problem. This was hardly orthodox reasoning.

On May 2, 1918, Major Crocker arrived at the Brooklyn base. Within the 18 months that followed, this vast terminal for handling the shipping of overseas supplies was practically completed. As Constructing Quartermaster, he directed the work of the general contractor. In all the confusion of wartime, and with all the handicaps of uncertain labor, he successfully completed the huge project, consisting of piers, loading docks, concrete warehouse, and railroad yards—then the largest single construction of its kind in the world. During the course of this work, he was promoted to Lieutenant Colonel in the Quartermaster Corps. Though he was naturally not concerned, except in a supervisory capacity, with the architectural design of the project, it is worth noting that this structure, built in wartime, is referred to by architectural critics as one of our outstanding examples of "engineering architecture"; there was never good architecture without good engineering construction. The unorthodox reasoning which led to his appointment appears to have been justified.

The war over, Colonel Crocker returned to Colorado, and in 1922 served on the Board of Review of Denver's water supply and distribution. He has since assisted in the solving of many of its water problems, including the diversion of water from the West Slope through the pilot bore of the Moffat Tunnel. He also built another viaduct, again in concrete, on 16th Street. During this time the question of flood control was engaging the attention of the City of Pueblo. The Pueblo Conservancy District had been established; and Colonel Crocker, who was appointed consulting engineer for the Dayton Morgan Engineering Company, designed and supervised the construction of bridges and viaducts involved in the flood control project of the district.

Shortly after the war Colonel Crocker also entered the contracting business, constructing a number of bridges in various parts of the Middle West. This work he has continued, distinct from his practice as a consulting engineer, up to the present time.

Much of Colonel Crocker's work during the past few years has carried him into Texas, but he maintains his office in Denver and still considers himself a resident of that city.

This sketch of a career will hardly serve for a sketch of the man. In defense, it may be said that Colonel Crocker's personality is probably better known among engineers than are the various steps by which he developed from a determined young surveyor to the President of the Society. Then again, it is no easy task to sum up his character in a few words. One of his dearest friends—who by the way, happens to be the oldest living Past-President of the Society—put it perhaps as well as it may be put when he wrote:

"He is a very unusual man. I have been trying to find him out for forty-odd years and am not yet able to diagram him. One of his peculiarities is that he always does better than you expected of him. When you look at him, it is hard to decide whether he is in earnest or joking or is thinking of something else, other than what you are telling him. But although you may expect him to fall off the train, or have a collision or something else happen to him, he is sure to arrive at his destination in fine form and able to 'deliver the goods.'"

In conclusion, it may be added that Colonel Crocker was admitted to the Society on October 2, 1901; served as Director from 1915 to 1917; served as Vice-President during 1919 and 1920; and was Acting Secretary of the Society in 1920. He has been a member of the Western Society of Engineers since 1906. For the past three years he has represented the Society as a delegate to the American Engineering Council.

Secretary's Abstract of Executive Committee Meeting

On December 14, 1931, the Executive Committee met at Society Headquarters with President Francis Lee Stuart in the chair. Present were: George T. Seabury, Secretary; Otis E. Hovey, Treasurer; and Messrs. Chester, Coleman, Mead, and Winsor. The incoming President, Herbert S. Crocker, was present by invitation.

Approval of Minutes

The minutes of the meeting of the Committee held on October 4, 1931, were approved as adopted by the Board.

Pamphlet of Engineering As a Career

Approval was given to the request of a committee of Engineering Foundation to cooperate in the preparation of a pamphlet on engineering as a career.

Society Badge in Publications

The Secretary was authorized to permit, under certain circumstances, the use of the Society badge in publications giving news of the several engineering societies or the local sections or student chapters of those societies.

American Engineering Council

Alonzo J. Hammond, M. Am. Soc. C.E., was appointed to act as the chairman of the Society's representation on the Assembly of Council, and in view of a proposed reduction in the budget of Council, selection was made of representatives to the Administrative Board.

Century of Progress: Chicago 1933

Approval was given to the holding of the 1933 Convention of the Society at Chicago in the week beginning June 25, 1933, in order that there may be joint participation with the other societies in an "Engineers' Week," during the Century of Progress Exhibition.

Proposed Budget for 1932

The Budget for 1932 was prepared for presentation to the Board of Direction at its meeting in January, and other routine matters of Society business were considered and acted upon.

Elections to Executive Committees of Divisions

On January 5, ballots were canvassed for the election of new members to serve on the executive committees of the Technical Divisions. The administration of each of these Divisions, as provided for in its constitution, is vested in an executive committee composed of five members, one of whom is elected each year to serve for five years, so as to insure continuance of administrative policies. Each new committeeman is chosen by Division members from one or more names, not to exceed three, proposed by a nominating committee from the Division.

Results of the election of new members to serve for the next five years on the executive committees of the ten Divisions are now announced as follows:

- City Planning Division, Ulysses S. Grant, 3d, Assoc. M. Am. Soc. C.E.
- Construction Division, W. F. Way, M. Am. Soc. C.E.
- Engineering-Economics and Finance Division, E. P. Goodrich, M. Am. Soc. C.E.
- Highway Division, Julius Adler, M. Am. Soc. C.E.
- Irrigation Division, John E. Field, M. Am. Soc. C.E.
- Power Division, Frederick W. Doolittle, M. Am. Soc. C.E.
- Sanitary Engineering Division, H. Burdett Cleveland, M. Am. Soc. C.E.
- Structural Division, Jonathan Jones, M. Am. Soc. C.E.
- Surveying and Mapping Division, George F. Syme, M. Am. Soc. C.E.
- Waterways Division, L. C. Sabin, M. Am. Soc. C.E.

These men will take up their duties in connection with the activities of the Technical Divisions at the close of the Annual Meeting in New York.

Appointments of Society Representatives

BAXTER L. BROWN, ALONZO J. HAMMOND, JOHN P. HOGAN, AND CHARLES E. SMITH, Members Am. Soc. C.E., have been appointed Society representatives to the Administrative Board of American Engineering Council.

Professional Engineers Committee on Unemployment

Metropolitan New York's Organization Has Already Justified Its Efforts

By J. P. H. Perry, M. Am. Soc. C.E.
Chairman of Executive Committee, P.E.C.U.

In the course of its study of the problem of engineers' salaries, the Society's Committee on Salaries—Ernest P. Goodrich, M. Am. Soc. C.E., chairman—saw the necessity for a plan to meet the unemployment situation in the profession. This committee's report to the Board of Direction of the Society at its Fall Meeting in St. Paul in October 1931 was promptly and enthusiastically adopted. The report proposed the formation of working committees from the Local Sections, the collection of funds, the registration of unemployed engineers, and the use of engineers to supervise local projects of "made work." With slight modifications this outline was adopted by the Metropolitan Section in New York, which formed a volunteer group known as the Professional Engineers Committee on Unemployment. In the article which follows, Mr. Perry explains the extent of the organization thus formed and the results accomplished. The problem has shown itself to be a very large one and the committee sees the necessity for further effort, although gratifying results already have been achieved.

At the first meeting of the Professional Engineers Committee on Unemployment, known in New York as the P.E.C.U., which was held October 21, 1931, with representatives of all the Founder Societies present, it was decided that the engineering profession should carry on its own unemployment relief program. This decision was reached because the regularly constituted relief agencies in the New York City region held to an exceedingly rigorous standard of destitution, and further because part of the P.E.C.U.'s program was to prevent, as far as possible, the engineering profession from reaching this condition.

Later it developed also that it was exceedingly difficult to obtain information from those in need of relief. Engineers as a class have never been given to talking of their troubles. However, it was found that these men would speak more freely to another engineer than to a professional social worker.

A general committee of about forty members, consisting of engineers prominent in the profession, whose names were ample evidence of the high character of the undertaking, was immediately formed. This general committee appointed an Executive Committee of six men to carry on actively the work of soliciting funds and of unemployment relief. This committee directs some dozen standing committees, which are divided, roughly, into two groups: those subsidiary to a Finance Committee, chiefly concerned with the collecting of funds; and those working under a Relief Committee, providing direct relief in such forms as employment, loans, legal aid, and engineering education.

Engineers Canvassed to Obtain Basic Data

The first step was to register the number of unemployed engineers in order to get an accurate estimate of the problem with which the P.E.C.U. was confronted. A postcard was first sent out to the metropolitan membership of the four Founder Societies advising them of the formation of the committee, stating that its object was to devise methods by which engineers in need of assistance would be looked after by their brothers in the profession, and also advising members in a position to do so to be prepared to contribute to the movement.

A tentative organization was formed, headquarters established in the Engineering Societies Building, New York, and preparations made to register the engineers as soon as they came in. At a mass

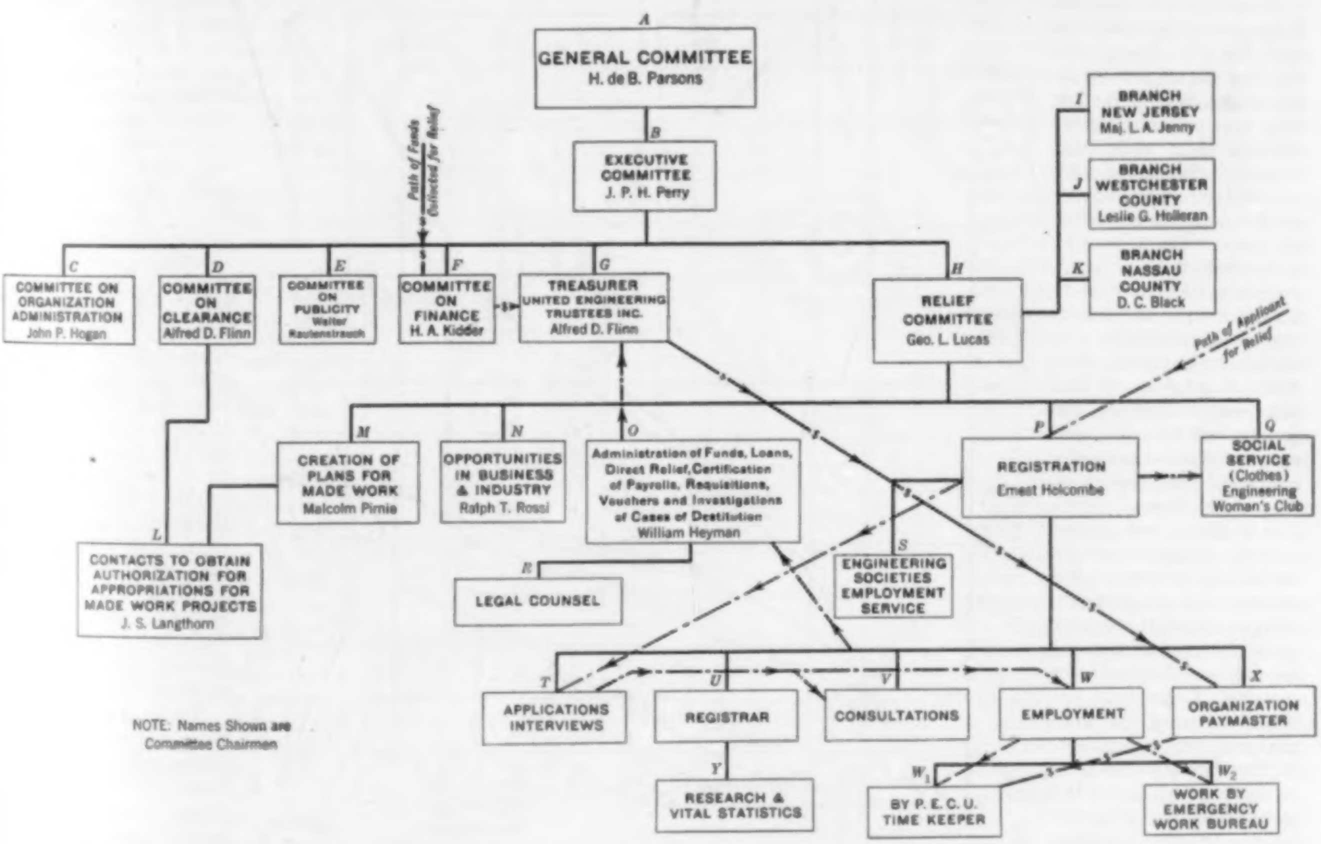
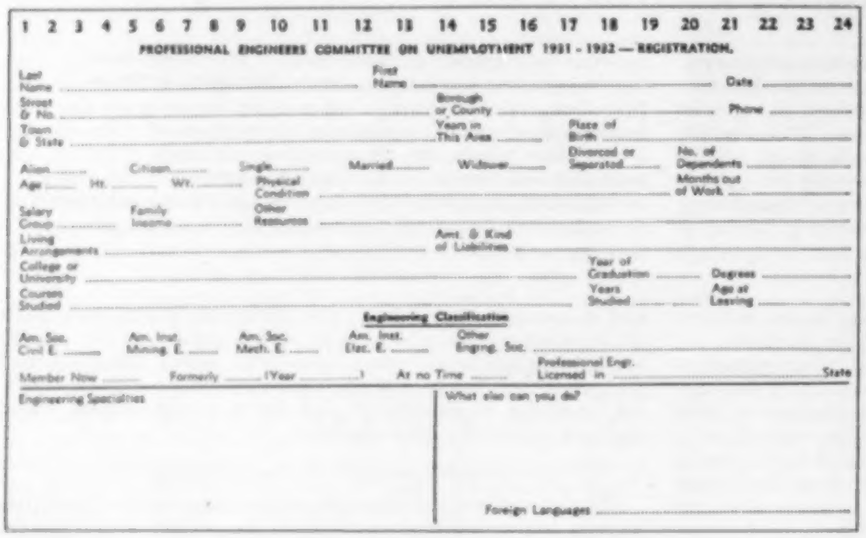


Fig. 1. Organization Chart of the Professional Engineers Committee on Unemployment, New York

meeting held in the Engineering Societies Auditorium on November 9, 1931, prominent speakers outlined the program to be carried out and also called for suggestions. The notice of the meeting carried this paragraph: "If you are unemployed and in need of assistance we urge you to register in person before November 10, at Room 201, 29 West 39th Street, New York City." Registration was very slow



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

PROFESSIONAL ENGINEERS COMMITTEE ON UNEMPLOYMENT 1931 - 1932 — REGISTRATION.

Last Name .... First Name .... Date ....
Street & No. .... Borough or County .... Phone ....
Town & State .... Years in This Area .... Place of Birth ....
Alien .... Citizen .... Single .... Married .... Widower .... Divorced or Separated .... No. of Dependents ....
Age .... Ht. .... Wt. .... Physical Condition .... Months out of Work ....
Salary Group .... Family Income .... Other Resources ....
Living Arrangements .... Amt. & Kind of Liabilities ....
College or University .... Year of Graduation .... Degrees ....
Courses Studied .... Years Studied .... Age at Leaving ....

Engineering Classification

Am. Soc. Civil E. .... Am. Inst. Mining E. .... Am. Soc. Mech. E. .... Am. Inst. Elec. E. .... Other Engrng. Soc. ....
Member Now .... Formerly .... (Year ....) At no Time .... Professional Engr. Licensed in .... State

Engineering Specialties

What else can you do?

Foreign Languages ....

FIG. 2. A REGISTRATION CARD IS FILLED OUT IN DUPLICATE

at first but increased rapidly from day to day as the movement gathered impetus.

Two policies were stated definitely at the beginning of the movement: that the P.E.C.U. in affording relief would make no distinction between members and non-members of the four Founder Engineering Societies; and that all moneys collected for relief would be applied to relief purposes only, the necessary administrative funds to be obtained from other sources.

From the very first, the Executive Committee of the P.E.C.U. recognized that its problem from an administrative point of view was relatively more difficult than that confronting the great city committees whose principal duty was the collection of funds. Once funds were collected by such committees they were turned over to the organized charities of the city for distribution. The P.E.C.U., however, had not only to collect the money but also to build up an organization wholly composed of engineers, who were largely volunteer workers and almost entirely inexperienced in social welfare work. The problem was one of organizing to spend the money with justice and without leaving any loophole for scandal. Great care has been exercised in safeguarding the expenditure of these moneys, not only in making just loans but in handling payrolls carefully. In the organization chart, Fig. 1, the line

FIG. 3. CURVES SHOWING CUMULATIVE REGISTRATIONS AND JOBS FOUND

interrupted by dollar signs shows how the funds are handled within the organization, from their collection to their disbursement in the form of loans or payrolls.

"MADE WORK" BUREAU ESTABLISHED

One of the first steps was to make contact with the regularly established relief organization, Emergency Work Bureau II, which is the New York branch of the President's Organization on Unemployment Relief and which had already established a "made work" bureau in connection with the general unemployment relief program of this city.

The advantage of having this "made work" carried out with proper engineering supervision, in order that the results might be of lasting benefit to the community, was pointed out to the executives of the Emergency Work Bureau II, and the cooperation of the P.E.C.U. was offered to secure this necessary supervision. The offer was accepted and the cooperation of these officials became an important contribution to the success of the movement. It was found, however, as already pointed out, that the "destitution requirements" of these regularly appointed agencies were such that many engineer applicants in need of help were unable to qualify. It was therefore necessary for the P.E.C.U. to establish its own "made work" bureau in order to find employment for cases which could not be taken care of by the other agencies.

More recently the State of New York Emergency Work Commission established a bureau called City Commission Work Bureau and adopted the principle of engineering supervision already established by the Emergency Work Bureau II.

AN ORGANIZATION OF ENGINEERS DEVELOPED

By a gradual process of evolution the organization of the P.E.C.U. has become what it is at present, as shown in the organization chart, Fig. 1. As already noted, the active work of the P.E.C.U. is directed by an Executive Committee, which supervises some dozen operating committees—indicated by the letter *B* on the diagram. Reporting directly to the Executive Committee is a Committee on Clearance, *D*, whose chief duty is to maintain contacts with existing relief agencies such as those already noted. A Committee on Organization, *C*, takes care of problems of internal administration and also acts as comptroller of the administration funds. There is also a Publicity Committee, *E*, charged with the publication of suitable material in both the daily and technical press. The remainder of the work is divided into two groups, financial and relief.

The work of the Finance Committee, *F*, is concerned with the raising of funds for relief purposes only. This has been done so far by appeals made to the metropolitan district

members of the four Founder Societies, principally by letter. There has been made, however, a special list of engineers who are believed to be in a position to make sizeable contributions, and members whose names are on this list have been approached by direct solicitation.

Moneys collected by the Finance Committee are deposited with the United Engineering Trustees, Inc., which acts as Treasurer, *G*, of the P.E.C.U. There are many obvious advantages inherent in the use of an established concern for this purpose.

The general function of the Relief Committee, *H*, is direct and indirect relief in all its forms, together with the developing and proper prosecution of plans for "made work." It will be perhaps easier to present a picture of the working of this committee by following for a moment the path shown on the organization diagram by the dash line, that of an engineer presenting himself for assistance from the P.E.C.U.

The applicant first presents himself to the Committee on Registration, *P*, where he fills out duplicate cards, one of which is shown in Fig. 2. The reverse side of these cards contains spaces for information as to his last two positions. One of the cards goes to the Registrar, *U*, who determines his engineering status and decides whether it entitles him to relief from the committee. The other card is filed with the Committee on Research and Vital Statistics, *Y*, and suitable metal tabs are attached to the upper margin for purposes of cross reference. These guides show the applicant's so-called "degree of destitution" as follows:

1. If in need of immediate aid
2. If his resources will last one month
3. If his resources will last for longer periods

Preference in employment is always given to those in immediate need. The cross reference also shows the applicant's residence, whether he is a civil, mining, electrical, or mechanical engineer, and his salary classification. These cross references are useful when an order comes to the P.E.C.U. to produce, usually on short notice, a number of men to do a certain class of work.

The engineer is next interviewed by the Department of Employment, *W*, which first endeavors to place him immediately in some gainful occupation. If he is a member of one of the Founder Societies he is also automatically registered with the Engineering Societies Employment Service for a permanent position.

In the course of the interview by the Registration Committee, *P*, the interviewer attempts to ascertain whether the engineer requires immediate financial help or legal advice. If he is in need of such relief he is sent next to the Department of Certification of Loans and Payroll, *O*, where his case is investigated. In the event that this form of relief is approved, he is given a requisition on the Treasurer for a loan, in return for which he gives his note, which is non-interest bearing and payable on demand.

Should an applicant be in immediate need of clothing it is made available to him by the Social Service Committee, *Q*, which is sponsored by the Engineering Woman's Club. It frequently develops that the applicant is merely in need of sound advice or legal assistance, in which case such advice is made available without expense by Counsel, *R*.

One class of problem with which the P.E.C.U. has to cope is that presented by engineers who are not in any particular financial distress but who are suffering from severe mental depression due to their loss of occupation. Arrangements have been made with Columbia University whereby these men are admitted to lecture courses on engineering and allied subjects, without fee and without academic credit. It has been pointed out to such applicants that while employed they had little time to study but that now they have an opportunity to improve their professional status and place themselves in a position to increase their earning capacity at the end of the economic depression. In this way they will be able to make increased future earnings pay for past idleness. To date 95 men have registered in these courses at Columbia University.

The function of the Committee on Plans, *M*, is to survey and chart the possibilities for "made work" and the allied committee, *L*, is charged with the responsibility of putting these plans into effect. The Committee on Opportunities in Business and Industry, *N*, which started to function the first of the year, will make contacts with various business and industrial organizations, bringing to their attention the possibilities of having their plants surveyed by unemployed engineers with a view to improving plant layout and processes of manufacture, and increasing efficiency.

Permanent Positions Also Provided

As previously mentioned, contact is maintained between the Registration Committee, *P*, of the P.E.C.U., and the Engineering Societies Employment Service to provide permanent positions, if available, for the registrants. These two bodies are, however, entirely separate.

The Engineering Societies Employment Service (known as the E.S.E.S.) is a country-wide bureau supported by the Founder Societies to provide permanent positions for members of these societies only. It is financed from the dues of all members and from contributions paid in by those receiving permanent employment. It places in permanent positions those engineers who fulfill the specific requirements of employers, at salaries commensurate with the engineering services required.

The P.E.C.U. is instituted to provide prompt relief for engineers in immediate need. It registers all engineers out of work. It is financed by voluntary gifts, and it places in emergency positions those engineers who are in need of the limited pay available from contributed funds.

The registration or information cards prepared by applicants automatically pass through the E.S.E.S., and those who are members of the Founder Societies thus are registered for permanent positions in accordance with national procedure. Preference is given to members in a destitute condition in filling permanent positions, inquiry for which originates in the metropolitan district, and E.S.E.S. calls upon P.E.C.U. for such additional help as may be necessary in connection with the filling of these positions.

In Fig. 3 is reproduced a chart which is presented at the weekly meetings of the Executive Committee of the P.E.C.U. by the Department of Registration to show the progress being made toward the solution of the unemployment problem. Contact with registrants is maintained by the Department of Registration by mail, telephone, or otherwise, in order that it may be advised of any change in their condition. As a result of these inquiries the records are revised from time to time, as it has been found that many men occasionally find

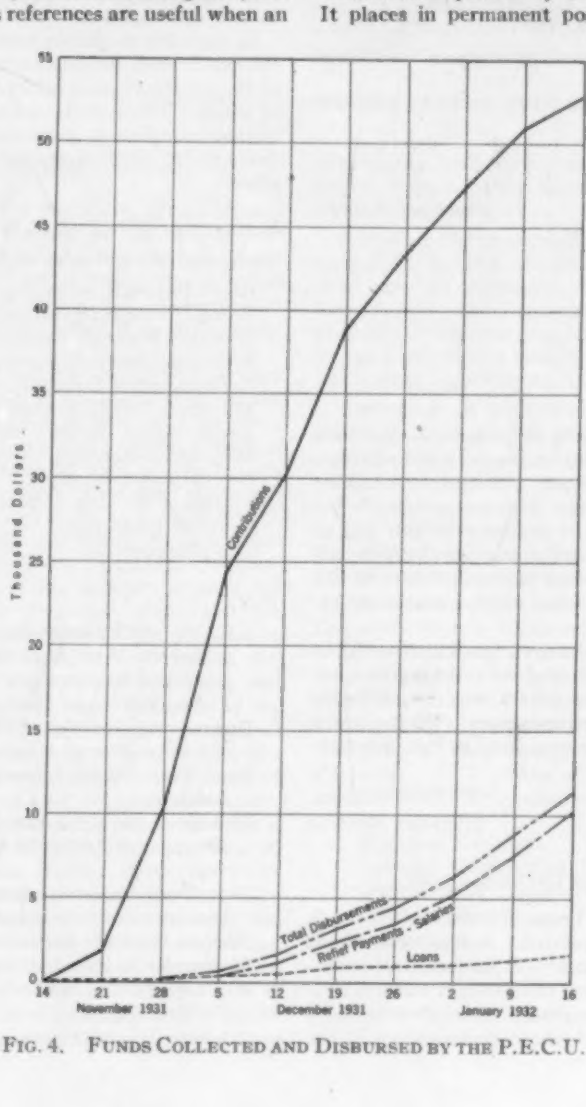


Fig. 4. Funds Collected and Disbursed by the P.E.C.U.

positions without assistance. These are therefore dropped from our lists. The vertical drop in the registration curve on January 8 is due to one of these reclassifications.

Employed Engineers Have Generously Subscribed

The results obtained to date are summarized in the following table giving the situation on January 19, 1932.

Amount collected in cash	$53,586.83
Unpaid pledges to date	18,054.27
Contributed for administration of the P.E.C.U.	2,822.97
State and Federal contributions to carry on the work of the U.S. Geological Survey, using men registered with the P.E.C.U. (approximately)	24,000.00
Total wages paid to P.E.C.U. men by others than the P.E.C.U.	59,363.00
Total	$157,827.07
Certain funds contributed with the stipulation that the relief should be extended to the entire United States (This relief is in the hands of a special committee appointed for the purpose by the four Founder Societies)	5,683.35
Total dollar benefit obtained for the engineering profession by the P.E.C.U.	$163,510.42

The report of the Finance Committee shows that 137 contributors from a special list of engineers produced approximately $25,400, an average of $185.40 each. From the general list, 1,400 engineers contributed $36,906.45 to the fund, an average of $26.36 each. The curves in Fig. 4 show the cumulative total of contributions at any given date, and the coincident disbursement in loans and wages. The original chart is used by the Executive Committee at its weekly meetings to determine future programs of solicitation and expenditure.

Of particular interest is the following letter, enclosing a contribution:

THE WHITE HOUSE
WASHINGTON
December 7, 1931.

Mr. H. deB. Parsons,
General Chairman,
Professional Engineers
Committee on Unemployment,
29 West 39th Street,
New York City.

My dear Mr. Parsons,

The devoted effort of your committee in securing employment and relieving distress among professional engineers has my sympathetic approval. I feel that the inherent administrative ability of American engineers to meet and cope with emergencies is sufficient assurance that any funds made available to you will be well administered and used to the best advantage, not only in finding useful employment, but by relieving individual cases of distress with small loans under liberal terms, which particularly appeals to me.

Having been informed that your committee intends, if sufficient financial support is forthcoming, to extend its activities to a national scope, I am enclosing check for $5,000, with no particular restrictions as to its use, but as an encouragement of the splendid spirit which has inspired you and your associates in this undertaking.

Yours faithfully,
HERBERT HOOVER

Immediate Loans Made to Critical Cases

The Committee on Certification of Loans investigates the condition of an applicant when a loan is requested. A man is considered destitute when he: (1) has no income; (2) has used all his resources and reserves; (3) has borrowed from friends and relatives to their limit; (4) owes rent and is in danger of, or already has, a dispossess notice; (5) can no longer obtain food on credit; (6) has no proper seasonal clothing for his dependents; (7) is threatened with having, or already has had, his gas and electricity shut off.

This certification committee has had to deal with many most grievious cases of dire need. The two following examples when cited to a prospective donor of funds for the use of P.E.C.U. produced a most substantial contribution.

An engineer 38 years old came in who had been out of work for eight months. He was married and had two children under three years of age. He had been living in a loft all summer but as winter approached was forced into an apartment where he paid $40 a month rent, helped out by keeping a roomer who paid $15 a month. He had recently lost a four-year old boy due to inadequate medical attention and he himself had been infected and had lain at death's door for four weeks. Previously he had sold his blood for transfusion purposes until through incompetence his arm was crippled so that he could no longer use it for that purpose.

The P.E.C.U. procured this man three-day work at $5 per day and in addition furnished him a job of research in the library at $15 a week, making a total of $30 a week. Also he was loaned $25 for his immediate needs until he got his first pay.

Another engineer, 59 years old, has lived with two married children who cannot contribute to the support of their parents and one boy, 24, at home, who has no regular income. This engineer, who has not worked since November 1930, has borrowed on his $3,000 insurance policy to the limit. He lives in his own home, which carries a $2,800 mortgage, on which interest was due January 1, 1932, amounting to $70 and unpaid taxes, about $250.

We have placed him in work which pays $30 a week, $15 paid by the Gibson Committee and $15 paid by the P.E.C.U. By arrangement with the bank, we advanced $75, for which it agreed not to take any foreclosure proceedings until June 1932.

The general policy of the P.E.C.U. is to investigate the applicant's statements of destitution or need of employment if he is not a member in good standing of one of the four Founder Societies, but members' statements are taken at their face value, without further investigation.

In the $11^1/_2$ weeks since the P.E.C.U. began to function on November 1, 1931, in addition to raising the money and securing jobs of the monetary value already stated, it has registered 1,483 men, of whom 1,019 were classed as destitute, and has placed 696 men in paying, temporary, positions. The following tabulation, dated January 19, 1932, shows the kind of work found for the men so placed.

Summary of Men Placed up to and Including January 19, 1932

Emergency Work Bureau (Gibson Committee)		
Bronx Borough, surveyors	37	
Bronx Borough Department of Water Supply	8	
Brooklyn Borough Department of Parks	7	
Richmond Borough, surveyors	1	
Department of Hospitals, mechanical specifications	3	
Municipal Building, plan examiners	5	
Traffic survey (in the 5 boroughs of New York City)	247	
Manhattan Borough, surveyors	10	
New York University	4	
College of the City of New York	2	
Board of Education	11	
Miscellaneous	19	354
P.E.C.U.		
P.E.C.U. staff (Committee on Registration; Committee on Vital Statistics; Branch Offices Committee on Registration; Volunteer Committee on Plans; Bureau of Placements)	49	
Engineering Societies Library (translations; repair of books; history, engineering)	7	
New York Public Library (research; translations; odd jobs)	15	
College of the City of New York (research; reconstruction of hydraulic laboratory; industrial survey)	29	
New York University (research; drafting on problem drawings; design of laboratory equipment)	10	
Stevens Institute (research; drafting; statistics)	23	
Malone & Graham (selling gasoline-saving device)	5	
Rex Cole (sale of electric refrigerators)	6	
P. H. Harrison, Inc., (sale of G. E. temperature regulators and electric refrigerators)	8	

New York Museum of Science and Industry (research; construction of models; machinists; guides and guards)	27	
Westchester County Park Commission (manual labor; design; planning)	46	
Bergen County, N.J. (triangulation work)	8	
Rutgers College (graduate studies in hydraulics; breakdown of dielectrics)	5	
Nassau County (surveys)	3	
Miscellaneous individual employers (men who have obtained employment in permanent positions either from the Engineering Societies Employment Service or from their own endeavors and are being paid by individual employers. These men are working on definite engineering jobs in their particular line of engineering)	40	282

City Commission Work Bureau:

City Commission Work Bureau staff	32	
U.S. Geological Survey	29	61
Grand Total		696

Distribution of men placed:

American Society of Mechanical Engineers	148 = 21.3 per cent
American Institute of Electrical Engineers	101 = 14.5 per cent
American Society of Civil Engineers	80 = 11.5 per cent
American Institute of Mining and Metallurgical Engineers	16 = 2.2 per cent
Non-members	351 = 50.5 per cent
Total	696 = 100 per cent

A complete summary of the activities of the P.E.C.U. is impossible because of lack of space. The organization is now functioning effectively and the movement for the relief of unemployed engineers in the metropolitan district of New York is in full swing.

The Finance Committee of the P.E.C.U. is about to undertake a direct personal canvass of some 600 affluent engineers in an endeavor to increase our larger contributions, and it hopes to make a direct house-to-house canvass of some 11,000 engineer members of the metropolitan sections of the four Founder Societies, who have not as yet responded to our appeals for contributions. The money in hand to date, plus pledges, will not even cover the most serious cases of destitute engineers from now until next summer.

This opportunity is taken to thank some 60 engineers who have been, and are largely still, serving as volunteer workers at P.E.C.U. headquarters in New York, not only the committeemen whose names are shown on the organization chart in Fig. 2, but also the workers whose names are not to be found there. Grateful acknowledgement is also made to the 1,400 engineers in the metropolitan area of New York who have contributed more than $70,000 in cash to date.

It is hoped that this description of the situation in the New York metropolitan area will be of help to other sections of the country, where the problem of unemployed engineers may also be urgent.

While the casual reader of this statement of the organization of the P.E.C.U. and of results produced to date might draw the conclusion that the situation is well in hand, such an impression would be unfortunate. Registrations are increasing each week as more engineers exhaust their final resources, but the collection of contributions is not increasing proportionately. Much of the winter is still ahead of us. New York City has curtailed its contributions to the unemployed relief work, with the probable effect on P.E.C.U.'s activities of curtailing the number of engineers that can be placed by municipal and other organizations. This will throw a vastly increased load on P.E.C.U. funds.

The Seventy-Ninth Annual Meeting

With a registration of nearly 1,800 members, students, and guests, the Seventy-Ninth Annual Meeting of the Society was called to order on January 20 by President Francis Lee Stuart for its initial session in the auditorium of the Engineering Societies Building. Every part of the United States was represented in the audience and at least one visitor was noted from as far away as Egypt.

On the platform were gathered a notable group of Honorary Members, Past-Presidents, and officers of the Society, when the morning session began with the ceremony of conferring honorary memberships on four distinguished members. The places of these four on the stage were then taken by another group of six members who were presented with the Society's medals and prizes for excellent papers previously published in Proceedings.

In each case the member to receive the honor or award was presented to the President in a short speech by a fellow member, generally a friend of long standing. This speaker outlined the career and accomplishments of the recipient, whereupon the President conferred the honor by handing him the diploma or medal. Thus the stage presented a kaleidoscopic view of distinguished engineers, Honorary Members, Past-Presidents, and prize winners. It was remarkable that each recipient of an honorary membership and every prize winner was present to personally receive his award. Photographs and brief biographies of those thus honored have already appeared in previous issues of Civil Engineering so that their names need not be repeated here.

Since 1927 each retiring President has been presented with a gavel—the identical silver-banded gavel which he has used so faithfully during his tenure of office. Before that year Past-Presidents received no suitable memento of their year of service to the Society. To remedy this omission, and to indicate the esteem in which they are held by the whole Society, each living Past-President was presented this year with a silver-banded gavel engraved with his name and the year of his office. It is especially interesting to note that of the 12 living Past-Presidents to receive these tokens of faithful service, 8 were present on Wednesday morning to accept their gavels in person. In this simple way, a fitting token of appreciation for service well performed was bestowed.

Following the presentation of gavels, the tellers' report on the final ballot for new officers to serve the Society during 1932 was read and the successful candiates were declared duly elected. The report itself appears on another page. President-elect Herbert S. Crocker was then escorted by two Past-Presidents to the rostrum and installed by President Francis Lee Stuart as the Society's guiding executive for 1932.

Attendance at the buffet luncheon in the Engineering Societies Building at noon on Wednesday was more than 400. Here advantage was taken of an excellent opportunity to make new contacts and renew old acquaintances while partaking of the excellent viands prepared. With a plate of food in one hand and a cup of coffee or a dessert in the other, the members circulated about the floor to seek familiar faces, or they talked in interested groups during the hour and a half allotted to luncheon.

The afternoon was devoted entirely to papers presented before the newly formed Engineering-Economics and Finance Division—the youngest of the Technical Divisions, which is growing rapidly. An enthusiastic group of 220 listened to this program. In the evening the formal dinner dance took place at the Roosevelt Hotel, a brilliant affair attended by about 450.

Thursday was devoted to concurrent sessions of the Technical Divisions. As a matter of record the attendance at the various sessions of the Divisions was approximately as follows:

Highway Division	70
Sanitary Engineering Division	150
Construction Division—Structural Division, in Joint Session:	
Morning	375
Afternoon	400
Power Division	100
Surveying and Mapping Division	70
City Planning Division	100

Much interest was shown in each of these technical meetings and discussion became lively in many of them. Attendance figures are not necessarily a criterion either of the interest called forth by a session or of the excellence of the program of speakers presented, but they indicate at least that the Divisions have made for themselves a very definite place in the work of the Society, and that members are interested in the technical phases of Society activities.

Judging from the number of members present, the Smoker and entertainment on Thursday evening was a very successful affair. The committee in charge selected a program of magic—half devoted to high frequency electrical demonstrations, photo-electric tubes and light valves; the other half to a fascinating exhibition of sleight of hand—which proved very popular. The 1,100 men present taxed the capacity of the auditorium and its gallery.

The inspection trip on Friday required a caravan of de luxe buses to convey all who desired to go on an all-day circuit of the fine bridges across the Hudson, the Passaic, and the Hackensack rivers as well as the structures spanning the arms of New York Harbor between Staten Island and New Jersey. On Saturday visitors were divided into three groups, those taking a trip to Wards Island in the East River, where the Tri-Borough Bridge is under construction; those who went to the Brooklyn Navy Yard; and those who entrained early to participate in two separate inspection trips in Westchester County. Of the latter group a part were taken in automobiles by the engineers of the Westchester County Park Commission on an inspection of the parkway system, and a part were conducted by the staff of the Westchester County Sanitary Commission to visit the principal sanitary developments along Long Island Sound and the Hudson River. In spite of adverse weather conditions, the inspection trips proved to be a source of profit and pleasure to the 300 engineers who attended.

The committee in charge of local arrangements, of which William L. Hanavan, Assoc. M. Am. Soc. C.E., was chairman, is deserving of the commendation and thanks of those in attendance at the Annual Meeting. These affairs cannot be arranged for without a lot of work, ingenuity, planning, and patience. The ladies of the party were entertained during the week by a special committee headed by Mrs. Hanavan. She and her assistants arranged and carried through a splendid social program.

Pictures for Engineering Schools

Appeal has been made repeatedly to Society Headquarters for aid in obtaining suitable large pictures for hanging on the walls of institutions of engineering education. Some institutions have expressed a desire for portraits of outstanding figures in early engineering history, such as Leonardo da Vinci, while others wish views of ancient engineering works, such as the Ponte Rotto in Rome.

The most recent appeal comes from the Brooklyn Polytechnic Institute, which asks for large and attractive views of modern engineering projects for the walls of its new engineering annex. Highway and surveying subjects are particularly desired at the present time. Acting as a clearing house between the colleges and those who are in a position to donate suitable pictures, the Society will be glad to give proper attention to communications from donors directed to Society Headquarters.

1931 BOARD OF DIRECTION OF THE SOCIETY

At its closing session on January 19, 1932, the 1931 Board of Direction completed the year's business in the Board Room at Society Headquarters. Beginning at the nearest corner of the table and proceeding around it in a clockwise direction, those present were:

(1) Charles A. Mead, Director, District 1
(2) Edward P. Lupfer, Director, District 3
(3) A. F. Reichmann, Director, District 8
(4) Frank E. Winsor, Vice-President, Zone I
(5) Henry R. Buck, Director, District 2
(6) J. F. Coleman, Past-President
(7) H. D. Mendenhall, Director, District 10
(8) Frank L. Nicholson, Director, District 5
(9) J. N. Chester, Vice-President, Zone II
(10) Joseph Jacobs, Director, District 12
(11) E. K. Morse, Director, District 6
(12) Charles H. Stevens, Director, District 4
(13) H. M. Waite, Vice-President, Zone III
(14) F. C. Herrmann, Director, District 13
(15) Allan T. Dusenbury, Director, District 15
(16) Roy C. Gowdy, Director, District 16
(17) Franklin Thomas, Director, District 11
(18) Ole Singstad, Director, District 1
(19) John R. Slattery, Director, District 1
(20) Miss Crook, Secretary to Mr. Seabury
(21) George T. Seabury, Secretary
(22) Francis Lee Stuart, President
(23) Otis E. Hovey, Treasurer
(24) Clyde T. Morris, Director, District 9
(25) L. G. Holleran, Director, District 1

Absent: J. M. Howe, Vice-President, Zone IV; Ralph Budd, Director, District 7; D. A. MacCrea, Director, District 14; and Anson Marston, Past-President.

Society Cooperation

One of the encouraging indications of professional collaboration—a straw which shows the direction of the current—was noticeable in the recent annual meeting of the American Institute of Chemical Engineers at Atlantic City, December 9–11, 1931. Among the main subjects for discussion on that occasion was the important engineering, as well as chemical, question of stream pollution. For this discussion, a number of members of the Society, men who were not chemists or members of the Institute, were given a prominent place on the program. Civil engineers and chemical engineers have long cooperated in some fields, most prominently perhaps in sanitation, of which the control of stream pollution is one of the most notable and successful examples.

Final Ballot on Society Officers for 1932

33 West 39th Street
New York, N.Y.
January 13, 1932

To the Seventy-Ninth Annual Meeting
American Society of Civil Engineers:

The tellers appointed to canvass the ballot for officers of the Society for 1932 report as follows:

Total number of ballots received		4,278
Deduct:		
Ballots from members in arrears of dues	47	
Ballots with printed or stamped signatures	6	
Ballots with illegible signatures	2	
Ballots not signed	72	
Ballots from members who have died since voting	1	
Total not entitled to vote		128
Ballots canvassed		4,150

For President

Herbert Samuel Crocker	4,127
Scattering	11
Blank	12

For Vice-Presidents

Zone I:

Arthur Smith Tuttle	4,117
Scattering	4
Blank	29

Zone IV:

David Christiaan Henny	4,115
Scattering	4
Blank	31

For Directors

District No. 3:

Edward Payson Lupfer	4,102
Scattering	2
Blank	46

District No. 5:

John Herbert Gregory	4,104
Scattering	2
Blank	44

District No. 7:

Henry Earle Riggs	4,106
Scattering	1
Blank	43

District No. 8:

Melvin Lorenius Enger	4,103
Scattering	0
Blank	47

District No. 9:

Robert Hoffmann	4,108
Scattering	0
Blank	42

District No. 12:

John Cyprian Stevens	4,105
Scattering	2
Blank	43

District No. 16:

Ernest Bateman Black	4,098
Scattering	8
Blank	44

Respectfully submitted,

Wallace L. Cadwallader, *Chairman*

Hans R. Jacobsen	B. B. Priest
Charles M. Madden	A. B. Fleck
Ph. Sander	George A. Sallans
H. A. Vanderbeek	Ernest B. Day
A. H. Henckel	Nathan I. Kass
Glenn S. Reeves	E. W. Clarke
C. E. Sudler	A. J. Wilcox
W. D. Volk	*Tellers*

Send in Your Professional Record

During December every member of the Society, in whatever grade, was sent a blank form for his biographical and professional record, with a request that this information be filled in, and the record returned to the file already established at Headquarters. This file was begun just ten years ago, and contained nearly 7,000 records when the recent forms were sent out.

An appeal for cooperation was enclosed. If members had filed records previously they were asked to bring them up to date; if not, they were requested to make their first statement for this valuable compilation. During the month that has elapsed, up to the time this issue is sent to press, about 1,700 men have responded to this request. This is over 11 per cent of the present membership of the Society.

It is earnestly desired, however, that many more would take advantage of the opportunity to have their professional records placed in this permanent file. In urging this, the Society has only altruistic motives. These records have been carefully indexed, not only under the names of the members, but under the branches of engineering which they designate as their specialties.

The file is in constant demand, usually for purposes of definite personal value to the members concerned. To allude to only one possibility, many requests for information are received having in mind the thought of employment. Even in these worthy instances, the chances are definitely against the finding of recent, or in fact of any, data for a particular member.

This is one service in which the Society, with all the good will in the world, can accomplish nothing by itself—only the member can give the information and only his own statement will be accepted. The value of having the listing complete and representative should be self-evident. Any member who has failed to receive his blank form or has misplaced it, may receive another by request to Headquarters.

Land Utilization Conference Meets

As an official representative of the Society, Sherman M. Woodward, M. Am. Soc. C.E., of the University of Iowa, attended a three-day conference on land utilization held in Chicago, November 19, 20, and 21. It is reported that this initial conference was a remarkable attempt to mobilize the best thought in the nation for the purpose of initiating a serious and well considered policy as to the best future use of all the lands of this country. The considerable progress reported was made possible in the short time available by the concentrated effort of able men, who pooled their knowledge and ideas to advance the public good. A report of the meeting is being made available for public distribution by the U.S. Department of Agriculture.

American Engineering Council

National representative of 26 engineering societies, with a constituent membership of 60,000 professional engineers, reports civil engineering news of the Federal Government

PROPOSED NATIONAL LEGISLATION OF ENGINEERING INTEREST

During the first few days Congress was in session several thousand bills were introduced. Most of these were private bills which appertained to individuals, such as those in regard to pensions. About one-fourth of the bills introduced were of public or general concern. Many of these were of engineering interest. This final group can be still further subdivided as follows: (1) those concerning which American Engineering Council has taken previous cognizance; (2) those that will receive the attention of Council at least through some one of its committees; and (3) those that are of local or sectional interest but that have engineering interest and content. The order in which the bills are listed below has no special significance.

Group 1. Bills recently introduced in the First Session of the 72d Congress, the subject matter of which has previously received the attention of American Engineering Council.

H.R. 6187. Mr. Green; December 17, 1931. To direct the Secretary of the Treasury to contract for architectural and engineering services in the designing and planning of public buildings.

S. 683. Mr. Smoot; December 9, 1931. To amend Section 13, Chapter 431, of an act approved June 25, 1910 (36 Stat. L. 855), so as to authorize the Secretary of the Interior to issue trust and final patents on lands withdrawn or classified as power or reservoir sites, with a reservation of the right of the United States or its permittees to enter upon and use any part of such land for reservoir or power-site purposes.

H.R. 4629. Mrs. Owen; December 8, 1931. Authorizing the Secretary of Agriculture to acquire toll bridges and maintain them as free bridges, and for other purposes.

H.R. 5837. Mr. Burtness; December 15, 1931. To regulate the construction of bridges over navigable waters of the United States, and for other purposes.

H.R. 78. Mr. Houston; December 8, 1931. Authorizing the Delaware and New Jersey Bridge Corporation; a corporation of the State of Delaware, domiciled at Wilmington, its successors and assigns, George A. Casey, of Wilmington, Del., Clifford R. Powell, of Mount Holly, N.J., their heirs, executors, administrators, or assigns, to construct, maintain, and operate a vehicular tunnel or tunnels under the Delaware River between New Castle County, Del., and Salem County, N.J.

H.J. Res. 40. Mr. Fish; December 8, 1931. To establish a commission to be known as a Commission on a National Museum of Engineering and Industry.

H.R. 107. Mr. Cochran; Dec. 8, 1931. To regulate the construction of bridges over navigable waters of the United States and for other purposes.

H.R. 299. Mr. Griffin; December 8, 1931. Providing for medals of honor and awards to Government employees for distinguished service in science or for voluntary risk of life and health beyond the ordinary risks of duty.

H.R. 411. Mr. French; December 8, 1931. To prevent erosion of soil, to protect the national watersheds, and to promote the highest general uses of the public domain, and for other purposes.

H.R. 435. Mr. Mapes; December 8, 1931. To provide for a deep waterway for ocean-going vessels from the Great Lakes to the Atlantic Ocean by way of the Saint Lawrence River and the Welland Canal.

S. 1200. Mr. Copeland; December 9, 1931. To establish a commission to be known as a Commission on a National Museum of Engineering and Industry.

Group 2. The bills listed below have been introduced into the First Session of the 72d Congress and referred to an appropriate committee or interested engineering organization. It does not necessarily follow that American Engineering Council will pass on any or all of these bills, but they appear to have sufficient interest to certain groups in the engineering profession to warrant investigation. Among these bills are:

S. 2419. Mr. LaFollette; December 21, 1931. To accelerate public construction during the present emergency, to provide employment, to create the Administration of Public Works, to provide for the more effective coordination and correlation of the public-works activities of the Government, and for other purposes.

S. 124. Mr. Brookhart; December 9, 1931. Providing for a five-day-work week for certain Government employees.

S. 264. Mr. Trammell; December 9, 1931. Providing that the members of the Interstate Commerce Commission shall be appointed from different sections of the United States, and that not more than one member shall be appointed from any one state.

S. 307. Mr. Hawes; December 9, 1931. To amend the Interstate Commerce Act, being "An act to regulate commerce," as amended July 29, 1906; April 13, 1908; June 13, 1910; February 17, 1917; March 2, 1917; May 29, 1917; August 10, 1917; and February 28, 1920, by providing a more adequate system of regulation for the railroads of the United States through an extension of the Interstate Commerce Commission and the creation of seven regional commissions to cooperate with and assist the Interstate Commerce Commission in the performance of its duties, and for other purposes.

S. 761. Mr. McNary; December 9, 1931. To aid in the maintenance of engineering experiment stations in connection with the colleges established in the several states under the provisions of an act approved July 2, 1862, and of the acts supplemental thereto.

S. 1234. Mr. Robinson; December 10, 1931. To authorize an emergency appropriation for special study of, and demonstration work in, rural sanitation.

H.J. Res. 1. Mr. Watson; December 8, 1931. To create a commission to cooperate with the States of Pennsylvania and New Jersey in preparing plans for the construction of the Washington Crossing Memorial Bridge across the Delaware River.

S. 2221. Mr. Waterman, Mr. Costigan, Mr. Bratton, Mr. Cutting, Mr. Sheppard, and Mr. Conally; December 17, 1931. Authorizing the construction of a drainage channel in the closed basin of the San Luis Valley in Colorado; authorizing investigations of reservoir sites, and for other purposes.

H.J. Res. 67. Mr. McSwain; December 8, 1931. To promote the general welfare, to regulate commerce among the several states, and to create fiscal agencies for the Federal Government, by authorizing a National Emergency Board, and by defining its powers.

H.R. 316. Mr. Huddleston; December 8, 1931. To provide capital for building homes, and for other purposes.

H.R. 333. Mr. Knutson; December 8, 1931. To regulate the level of water in certain reservoirs at the headwaters of the Mississippi River.

H.R. 400. Mr. Tinkham; December 8, 1931. Providing for the preparation of plans and estimate of cost of erecting a Hall of Fame.

H.R. 4650. Mr. Smith; December 8, 1931. To provide for the relief of farmers in any state by the making of loans to drainage districts, levee districts, levee and drainage districts, irrigation and/or similar districts other than the Federal reclamation projects or to counties, boards of supervisors, and/or other political subdivisions and legal entities, and for other purposes.

H.R. 5122. Mr. Carter; December 9, 1931. To provide for the storage for diversion of the waters of the North Platte River and construction of the Saratoga reclamation project.

H.R. 5304. Mr. Barbour; December 10, 1931. To provide for the aiding of farmers in any state by the making of loans to drainage districts, levee districts, levee and drainage districts, irrigation and similar districts other than Federal projects, counties, boards of supervisors, and other political subdivisions and legal entities, and for other purposes.

H.R. 5317. Mr. Ludlow; December 10, 1931. To create a Federal Industrial Commission to aid in the stabilization of employment in industry, agriculture, and commerce, and for other purposes.

If copies of any of these bills are desired they may be obtained by addressing a request to Elmer A. Lewis, Chief Clerk of the House of Representatives, Document Room, Capitol, Washington, D.C., or the Congressman from your district.

A Preview of Proceedings

As highways gain more and more in importance, the economic study of cantilever highway bridges also becomes of greater moment. The February number of PROCEEDINGS *will carry a valuable paper on this subject by a recognized authority on bridges. The second paper deals with the design of electrical transmission lines located along railroad rights-of-way, with towers bridging the tracks. A theoretical discussion of stresses set up in reinforced concrete due to changes in volume and to temperature variations forms the subject of a third paper. The issue will be completed by a progress report by the Structural Division's Subcommittee on Wind Bracing in Tall Steel Buildings and by discussions on current papers.*

Economic Proportions and Weights of Modern Highway Cantilever Bridges

In presenting the paper on economic proportions and weights of modern highway cantilever bridges, J. A. L. Waddell, M. Am.

Cooper River Highway Bridge, Charleston, S.C.

Soc. C.E., contributes another significant work to the voluminous literature with which he has already endowed the profession. The paper was inspired by consideration of the fact that the economic functions of modern highway cantilever bridges are likely to differ materially from those of old-time single-track railway cantilever structures. The newer bridges have comparatively great dead loads, more live loads, and wide roadways, whereas the older railway cantilevers have comparatively great live loads, small dead loads, and narrow roadways.

The principal economic function determined in this paper is the proportionate length of the suspended span for an ordinary three-span layout in terms of the main-span length, first, when the anchor arms are short, and second, when they are long. Three more important questions answered are:

1. What is the economic depth of truss over the main pier in terms of the main span length?
2. For the ordinary three-span cantilever layout, what is the economic length for the anchor span when the positions of the two main piers are given?
3. What is the economic proportionate length for the anchor arm of the ordinary three-span cantilever layout when the location of the anchor piers is given and the designer has a free hand as to the location of the two main piers?

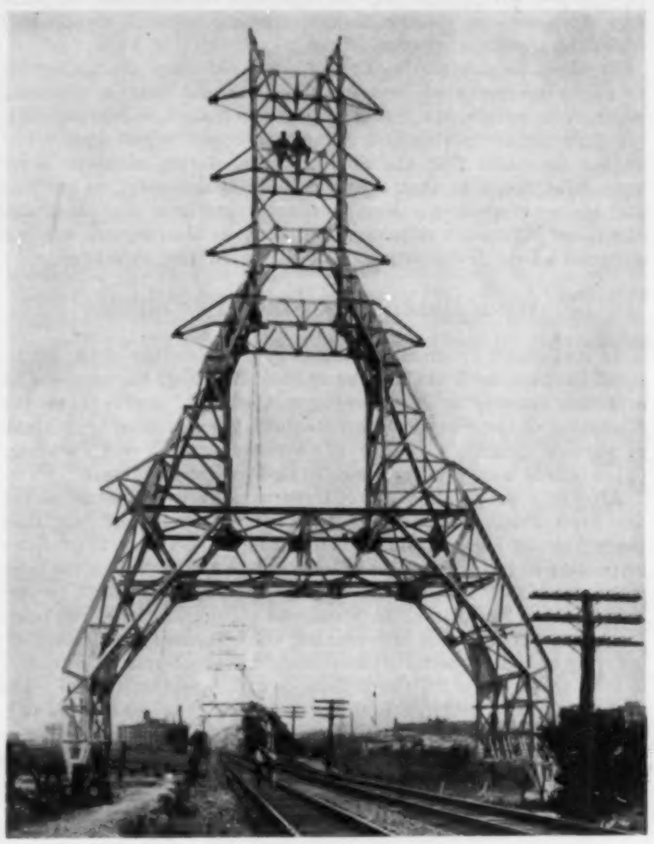
In formulating answers to these questions, Dr. Waddell draws liberally from a wide experience and presents important tabular data on the distribution of weights of material in highway cantilever bridges for various cases.

The following paragraph headings are presented for the purpose of making advanced appraisals of the scope and intrinsic value of this paper: Basic Data, Effect of Substructure, Short Cuts in Making Calculations, Economic Length of Suspended Span, Data from Computed Span, Effect of Substructure Variation, Effect of Method of Erection, Verification by Section Diagram, Economic Considerations Other Than Metal Weight, Economic Depth of Truss Over Main Piers, Economic Length for Anchor Arms with Fixed Length of Main Span, Economic Length for Anchor Arms with Fixed Distance Between Anchor Piers, Structure Having a Central Anchor Span, Two Cantilever Arms and Two Suspended Spans, Anchor Arm Span 300 ft., and Anchor Spans of 400, 500, 600, 650, and 700 ft. Results of these interesting researches are listed by Dr. Waddell in ten items at the end of his paper.

It is interesting to note that this is the ninth major paper that Dr. Waddell has given to the profession through this Society in addition to the numerous instances, during the fifty or more years of his affiliation, in which he has entered actively into discussion. That his work has always contained food for thought can be demonstrated in no more graphic manner than to state that every four pages of his original papers have elicited an average of seven pages of discussion. If it were possible to bind this interesting collection in a single book it would equal in volume a copy of TRANSACTIONS containing about 800 pages.

Design Characteristics of Reading Overbuild Transmission Line

Since March 1926, experience on the construction of the Conowingo Hydro-Electric development has yielded much valuable information to the engineering profession. The ultimate capacity of the power plant on this project, located near the town of Conowingo, Md., has been given as 594,000 hp. The energy thus generated is destined to supply power to the Philadelphia Electric Company's system at 220,000 volts. Although the dam and the power house are in Maryland, the upper half of the reservoir and



Typical "Bridge" on the Reading Overbuild Transmission Line

Supported on a Massive Concrete Foundation Reinforced with Special Structural Steel Cantilever Ribs

most of the transmission lines are located in the State of Pennsylvania. The forthcoming paper by Frederick W. Deck, Assoc. M. Am. Soc. C.E., will be concerned with the design characteristics of about $4^1/_2$ miles of transmission line constructed under unusual

working conditions over the right-of-way of the Reading Railroad.

After being transmitted for 57 miles at 220 kv., from the power plant at Conowingo, the current is redistributed from a large substation at Plymouth Meeting about 10 miles outside of Philadelphia. This is also the terminus of the 220-kv. lines connecting adjacent large systems in Pennsylvania and New Jersey. The power is carried at 66 kv. to a substation within the City of Philadelphia.

These transmission lines enter the city by two routes over two separate railroad rights-of-way. The first was built in 1928; it was in the second line, however, that difficulties of design and construction far greater than those encountered in the first were met. Mr. Deck's presentation is a valuable discourse on the art of designing transmission lines, but does not open for discussion details of mathematical analysis of this type of structure. A typical example of a transmission tower bridging the right-of-way is here illustrated. This is what the author terms the "bridge" type as distinct from the "tower" type. The subjects of proper design loads and general design procedure form an important part of this paper.

STRESSES IN REINFORCED CONCRETE DUE TO VOLUME CHANGES

Engineers in the field and in the designing room, professors and students in the classroom, alike will find material worthy of careful study in the paper by C. P. Vetter, Assoc. M. Am. Soc. C.E. The treatment is theoretical and covers concisely five isolated conditions of stress—due to shrinkage, swelling, temperature, combined shrinking and temperature, and finally, combined swelling and temperature. Formulas are presented in each case for the determination of minimum reinforcement, maximum temperature drop for minimum reinforcement, reinforcement for a greater temperature drop, critical volume change, distance between cracks, and minimum distance between cracks.

Of these formulas, Mr. Vetter says that they are applicable to such structures as concrete flumes, canal linings, retaining walls, road pavements, and floors in warehouses and large buildings, providing contraction joints have not been used. The author concludes that the greatest ratio of reinforcement is required for concrete that is subject, simultaneously, to swelling and temperature drop. Furthermore, he declares that shrinkage alone and combined shrinkage and drop in temperature are less dangerous than temperature drop alone, without shrinkage.

WIND BRACING IN STEEL BUILDINGS

In its Second Progress Report, the Subcommittee of the Structural Division on Wind Bracing in Steel Buildings has confined its attention entirely to the following matters: (1) comments on the discussion of the First Progress Report; (2) a method of analysis of shallow bracing systems; (3) arrangement of wind bracing; (4) details of wind bracing; and (5) new recommendations.

After considering the views of those who presented discussions of the First Progress Report and having regard to the fact that there has not been any large body of new experimental evidence respecting wind force made available during the past year, the Subcommittee is of the opinion that no modification in its recommended wind loading should be made at the present time. It holds to the view that taking into account the collateral stipulations respecting stability; permissible stresses in the material; allowances, if any, to be made for the resistance to be contributed by walls and partitions; and the limiting deflection, the wind force prescription should be adequate for any part of the United States or Canada. The Subcommittee is ready, however, to reconsider its recommendation whenever a sufficient body of new evidence may make it apparent that a revision is necessary.

In order to place the matter of permissible stress on a somewhat more satisfactory basis, the Subcommittee has made a recommendation of the permissible stress for members whose total stress includes percentages due to wind varying from 0 to 100. The provisions are so devised as to give a reserve of strength against increased wind load that is reasonably consistent with that realized in members in which dead- and live-load stresses predominate.

The Subcommittee reports that for buildings of moderate height, the Cross method of analysis of shallow bracing systems has been found to give a satisfactory degree of accuracy without undue expenditure of time and labor. By a slight extension of it the influence of length changes in columns can be taken into account. A method of computing the deflection of the frame from bending in the columns is proposed.

Typical arrangements of wind bracing in tier buildings are illustrated and discussed and some attention is given to the basic principles of design of satisfactory wind bracing details.

Summarizing its studies, the Subcommittee has presented ten definite conclusions and recommendations, all of practical value to the structural engineer. Also included is an appendix dealing with "Recommended Procedure in Moment Calculation for Shallow Bracing Systems." The entire report is being included in PROCEEDINGS in the hope that discussion will clarify any difficulties and tend to crystallize advanced opinion on this vital subject.

News of Local Sections

CINCINNATI SECTION

Over 100 members and guests attended a joint meeting of the Cincinnati Section with the Student Chapter of the university, which was held on Friday evening, December 18. The subject of the meeting was "The Essential Qualifications of a City Manager," and Col. H. M. Waite, who was a city manager when the profession was in its infancy, was the first speaker. Colonel Waite's talk was enthusiastically received. Other discussion of the subject was contributed by Col. C. O. Sherrill, former City Manager of Cincinnati; J. D. Ellis, who has acted as city manager on many occasions; and last, City Manager C. A. Dykstra, who summed up the points made by the other speakers and interjected many unique points of his own.

CLEVELAND SECTION

The Cleveland Section held a luncheon meeting on November 10. After the business session, W. C. Young, of the Goodyear Zeppelin Corporation of Akron, gave an interesting talk upon the problems of airship design, particularly with reference to the Akron. Among the guests present were 48 students from Case School of Applied Science.

A well attended meeting of the Cleveland Section was held on December 1. During the business session, the following officers were elected for 1932: Howard W. Green, President; R. F. MacDowell, Vice-President; and William L. Havens, Secretary-Treasurer. After that R. S. Marshall, Vice-President of the C. and O. Railroad, gave an interesting talk upon "Railroad Economics."

DISTRICT OF COLUMBIA SECTION

On November 19, Prof. Kyoji Suyehiro, Director of the Earthquake Research Institute of the Tokyo Imperial University, addressed a joint meeting of the District of Columbia Section, the Washington Academy of Sciences, and the Washington Society of Engineers. The subject of Professor Suyehiro's interesting talk was "Engineering Aspects of Earthquake Research in Japan."

GEORGIA SECTION

The speaker of the day at the regular November meeting of the Georgia Section was Frederick H. McDonald, former president of the Section and present secretary of the Engineering-Economics and Finance Division of the Society.

The special meeting of this Section, called to honor the visit of Francis Lee Stuart, President, and George T. Seabury, Secretary of the Society, was held on Friday evening, November 13, and was very well attended. An inspiring paper on "Engineers' Opportunities" was read by President Stuart, following which Secretary Seabury spoke on the general activities of the Society.

The local section of the American Society of Mechanical Engineers joined with the Georgia Section at their annual meeting, held on December 7, in order to hear an address on engineering registration. This address, given by H. D. Mendenhall, stressed registration as the most important single problem before the engineering profession today. At the business session of the meeting the following officers were elected for the coming year: C. C. Whitaker, President; and Ewing Humphreys and William A. Young, Vice-Presidents.

Illinois Section

At its meeting held on October 23, the Illinois Section endorsed the resolution adopted by the Board of Direction of the Society with reference to topographic surveys.

The luncheon meeting of this Section was held on November 6. After luncheon had been served, Colonel Crocker, official nominee for President of the Society, gave a short talk in which he described unemployment in New York and Denver.

Iowa Section

The November meeting of the Iowa Section was held in Des Moines on the twentieth. At this time the following officers were elected for the coming year: F. A. Nagler, President; C. H. Currie, Vice-President; and C. C. Williams, Director. "The St. Paul Conferences of Local Sections and Student Chapters" was the topic of a discussion by W. J. Schlick, President of the Section, and this was followed by an address by C. C. Coykendall, Administration Engineer of the Iowa Highway Commission on "Iowa's Primary and Secondary Road Programs."

After an informal dinner at the Hotel Fort Des Moines an interesting description of the Des Moines water works collection system and extensions of infiltration galleries was given by Charles B. Burdick, consulting engineer, of Chicago.

Kansas City Section

On December 1, officers for the Kansas City Section were elected as follows: A. N. Reece, President; T. J. Strickler and R. W. Waddell, Vice-Presidents; and J. A. Strang, Secretary-Treasurer.

Kansas State Section

An address by N. T. Veatch, of Black and Veatch, of Kansas City, Mo., was the feature of the Section's luncheon meeting held on November 17. The subject of Mr. Veatch's interesting talk was the responsibility of the Local Section.

Los Angeles Section

An address by Russell H. Ballard, President and General Manager of the Southern California Edison Company, entitled "A Message to Engineers," was greatly enjoyed by all attending the December 9 meeting of this Section. Following Mr. Ballard's talk, A. Whitaker, of the John A. Roeblings' Sons Company, showed an interesting and instructive motion picture of the construction of the George Washington Bridge across the Hudson River from New York to New Jersey. Officers for the coming year were elected as follows: A. L. Sonderegger, President; Merrill Butler, Second Vice-President; and Kenneth Volk, Treasurer. Ormond A. Stone becomes first vice-president, and Macy Jones continues as secretary for another year.

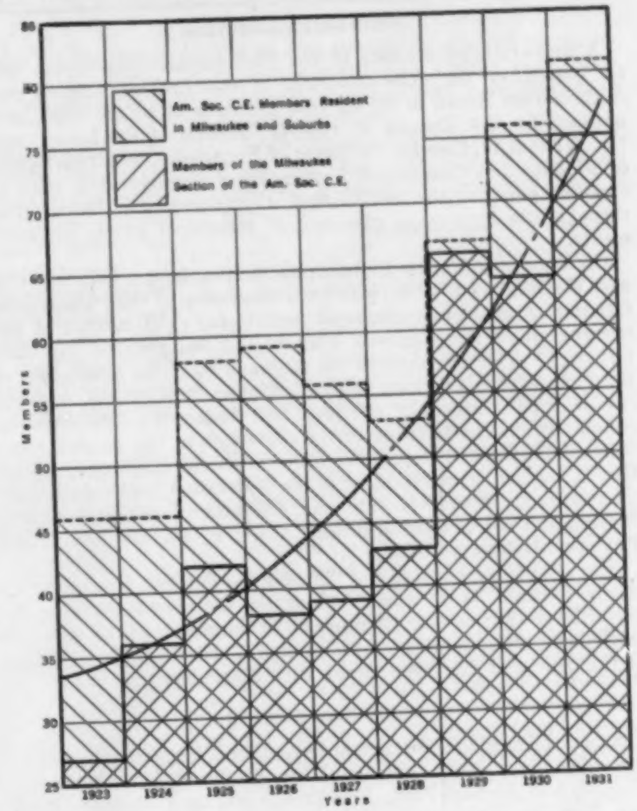
Metropolitan Section

At the regular monthly meeting of the Section, held on January 6, the history and present status of the "Delaware Water Supply" was outlined by Thaddeus Merriman, Chief Engineer of the New York City Board of Water Supply. The effect of the economic depression, he asserted, is only to stop the normal rate of increase in water consumption. Comparison of growth in available water and the increasing demand, which has now almost caught up with the supply available, forecasts difficulties until the new Delaware aqueduct is completed in 1939 or 1940. Many years of engineering study and interstate conferences finally led to the U.S. Supreme Court's approving in large measure New York City's claim to the use of the Delaware supply. The new aqueduct, about 135 miles long, will be entirely in rock tunnel. The time of completion will be governed by work on the longest section between shafts, 8 miles. Following this address, discussion was offered by J. Waldo Smith, Joseph Goodman, and C. S. Jarvis. A capacity attendance of about 600 enjoyed the meeting. Refreshments were served.

Milwaukee Section

A joint meeting of the Milwaukee Section and the Marquette University Student Chapter was held on Thursday, November 12. "The Japanese Earthquake of 1923" was the topic of an address by Professor H. L. Riordan, of the College of Business Administration at Marquette University, and French Consul in Milwaukee. This interesting talk was illustrated by lantern slides of the innumerable photographs which Professor Riordan took during the fire which resulted from the earthquake. His talk was both interesting and educational.

Business routine occupied the greater part of the monthly meeting of the Milwaukee Section, held on December 14. The following were nominated to office for the coming year: James L. Ferebee,



Progress Made by Milwaukee Section in Enrolling Members of the Society Resident in the Section

President; E. D. Roberts, First Vice-President; R. W. Gamble, Second Vice-President; and Frederick W. Ullius, Secretary-Treasurer. An address by Charles B. Bennett, City Planning Engineer for the City of Milwaukee, on a phase of city planning, proved to be of great interest.

New Mexico Section

A dinner meeting of the Section was held at Albuquerque on December 9. During the business session the following officers for 1932 were elected: R. G. Hosea, President; W. C. Davidson, First Vice-President; Edgar L. Barrows, Second Vice-President; and Wilbur B. Ream, Secretary-Treasurer.

Northeastern Section

There were 64 in attendance at the special meeting of the Northeastern Section held on December 11, which was attended by President and Mrs. Francis Lee Stuart; Secretary George T. Seabury; Mr. and Mrs. S. E. Killan, representing the Engineering Societies of Boston; and Mr. and Mrs. J. M. Newell, Jr. The Section also had as its guests representatives of six Student Chapters. "Things of Which We Are Proud," was the subject of an interesting address by Secretary Seabury, while President Stuart spoke on "Engineers' Relation to Progress."

Northwestern Section

A meeting of this Section was held on Tuesday, December 8. An interesting talk was given by Max Toltz of St. Paul, who spoke on "Unemployment and the Dole in England and Germany." In his talk he painted a very gloomy picture of conditions in England and Germany and concluded that both unemployment insurance and the dole were extremely undesirable. The following officers were elected for the coming year: George E. Loughland, President; M. W. Hewett, and Walter H. Wheeler, Vice-Presidents; and Hibbert Hill, Secretary-Treasurer.

Panama Section

The Panama Section reports the election of its officers for 1932 as follows: Col. J. L. Schley, President; Leopoldo Arosemena, First Vice-President; E. S. Randolph, Second Vice-President; and L. B. Moore, Secretary-Treasurer.

Philadelphia Section

A well-attended meeting of the Philadelphia Section was held on November 19. The functions of the Federal Employment Stabilization Board in its six-year planning of public work were outlined by Col. Donald H. Sawyer, director of the board; and Dr. William N. Loucks, Professor of Economics, Wharton School of Finance and Commerce, University of Pennsylvania, read an excellent paper on the stabilization of employment in Philadelphia through the long-range planning of municipal public improvements.

On December 15, the Philadelphia Section held a joint meeting with the Engineers' Club, with the cooperation of the Philadelphia Chapter, American Institute of Architects. The subject of the meeting was "The Regional Plan of the Philadelphia Tri-State District." The president of the Regional Planning Federation of the Philadelphia Tri-State District, Samuel P. Wetherill, outlined the principal features of the plan and discussed public policies. Among others contributing to the discussion of the subject were: William H. Connell, Executive Director of the Federation; Herbert L. Badger, Vice-President of the Federation in charge of public relations; Walter H. Thomas, Director of the Philadelphia Department of Architecture; and Albert F. Damon, Consulting Engineer, Delaware County, Pa.

The 1931 Year Book of the Philadelphia Section, which was recently released, is a valuable guide for the membership to the activities of the Section. A program of the meetings and speakers scheduled for the coming year as well as a résumé of the activities of the past year are given, along with other pertinent data.

Porto Rico Section

At a meeting of this Section on December 8, the following officers were elected for 1932; Etienne Totti, President; Ramón Ramos Casellas and Manuel Font, Vice-Presidents; and Reinaldo Ramirez, Secretary-Treasurer.

Sacramento Section

A number of interesting meetings of the Sacramento Section have been held during the last few months. Among the speakers at the various meetings were Assemblyman Van Bernard; John A. Beemer, who recently returned from service in Russia; Lieutenant Kelsey, U.S.A.; H. F. Lusk of Sacramento Junior College; Henry D. Dewell; T. E. Stanton; and Mario Palmieri, of the State Highway Bridge Department. On November 24, a motion picture showing the manufacture of portland cement by the Calaveras Cement Company was shown. There were 42 members and guests present.

Seattle Section

An illustrated presentation of the "New Structural and Architectural Uses of Reinforced Concrete" was given by H. M. Hadley, Regional Structural Engineer, Pacific Coast States, for the Portland Cement Association, at the regular monthly meeting of the Section held Tuesday, November 24.

St. Louis Section

The St. Louis Section at its annual meeting, held November 23, elected the following officers for the coming year; F. G. Jonah, President; L. R. Bowen, First Vice-President, Francis T. Cutts, Second Vice-President; and R. A. Willis, Secretary-Treasurer.

Tacoma Section

Thirty members were present at the meeting of the Tacoma Section, held on November 9, at which C. E. Putnam, City Engineer of Tacoma, spoke on "The Putnam Plan for the Reorganization of the State of Washington," and A. M. Truesdale, Bridge Engineer of the City of Tacoma, showed moving pictures of the most interesting features of the Eleventh Street Viaduct just completed.

At its meeting on December 14, the Tacoma Section elected the following officers for the coming year: C. E. Putnam, President; W. A. Kunigk, Vice-President; Walter J. Ryan, Director; and Julian Arntson, Secretary-Treasurer. The speaker of the meeting, Charles H. Williams, City Engineer of Olympia, told of the reconstruction and development of the Olympia water system in recent years, and Edward L. Greene, Project Engineer of Olympia, supplemented the address with pictures of construction details.

Toledo Section

As a result of the election held at the annual meeting of the Toledo Section, on December 15, the following men will hold office for the coming year: Alexander S. Forster, President; William G. Clark, Past-President; George Champe, First Vice-President; Halvor O. Hem, Second Vice-President; and Porter W. McDonnell, Secretary-Treasurer.

Student Chapter News

College of the City of New York Student Chapter

On November 5 at 12:30, Col. John R. Slattery, of the Board of Transportation, spoke to the Chapter on "Some Reminiscences of Engineering Experiences." Colonel Slattery has been in active charge of subway construction in New York City.

Ohio Northern University Student Chapter

At the December 8 meeting of this Chapter an illustrated lecture on "Coolidge Dam" was given by Donald Dougherty. His talk was greatly enjoyed by all present.

Ohio State University Student Chapter

During the past quarter this Chapter held two dinner meetings on the campus. The speaker at the October meeting was C. P. Hoover, chemist for the Columbus Water Works, and at the November meeting, Ole Singstad, Consulting Engineer for the Holland Tunnel project. Both of these lectures were illustrated and of great interest.

Pennsylvania Military College Student Chapter

The first meeting of this Chapter took place on October 9 with 21 members in attendance. The following officers were elected for the coming year: Herbert P. Meitner, Chairman; Morton L. Rabinovitch, Vice-President; and William F. Endress, Secretary-Treasurer.

The November 20 meeting was the formal installation meeting of the Chapter, and 36 members and guests were present. The speakers were: Charles H. Stevens, Director of the Society, who spoke on the function of the Society; James W. Follin, President of the Philadelphia Section, who spoke of the functions of the Local Sections; and Col. C. E. Myers, the Chapter's Alumni Sponsor, who told of the functions of the Student Chapters. Remarks and comments were added by Prof. W. H. Barton, Jr., head of the Civil Engineering Department. The meeting, which was thoroughly enjoyed by all, was followed by a buffet supper.

At the December 11 meeting a lantern slide lecture on the Conowingo Hydro-Electric Development was given by Morton Rabinovitch.

University of New Hampshire Student Chapter

At a recent meeting of the Chapter, informal talks were given by Prof. Edmond W. Bowler, head of the Department of Civil Engineering, and Charles O. Dawson, instructor in Civil Engineering. After a short social period, the group adjourned to the lecture room where lantern slides of the Cascade Tunnel were shown.

At a recent meeting of the Chapter informal talks were given by Prof. Edmond W. Bowler, head of the Department of Civil Engineering and Charles O. Dawson, instructor in Civil Engineering. After a social period the group adjourned to the lecture room where lantern slides of the Cascade Tunnel were shown.

Virginia Military Institute Student Chapter

The regular bi-monthly meeting of the local Chapter was held on Saturday morning, October 24. Various interesting discussions were given by members of the student body, on such subjects as "The Coolidge Dam," "Gravel Washing," "The Jones Park Development," and "Hydraulic Fills."

ITEMS OF INTEREST

Engineering Events in Brief

Land and City Surveys Insured

Besides the accurate use of surveying instruments, the theory and practice of locating property lines requires professional knowledge and skill, careful investigation of conditions, good judgment, proper analysis of data in the determination of facts, and the ability to apply the statutes to the facts in the case.

Reputable surveyors have witnessed with alarm the growing tendency toward a lowering of professional standards in the practice of their profession. They realize that the inevitable result of work by incompetent surveyors is boundary disputes and strife, which are often disastrous. The final result of a survey is indicated on a sketch or plat, but the public has no means of knowing how much skill, effort, and study have been spent in obtaining the results represented.

To protect and safeguard the rights of the property owner as well as of the competent surveyor, a new society, known as the New York State Institute of Insured Surveyors, has been incorporated. The salient feature of membership in the institute is that surveys prepared by members will be covered by an adequate insurance policy, issued by an outstanding company. This will indemnify the insured against loss resulting from legal action for any alleged error or mistake.

The institute was organized in the Borough of the Bronx, New York, and sections or chapters are in the process of formation in various counties throughout the state.

Tree Roots Grow in Shape of Girders

In studying root formations in bogs near Seattle, Prof. George B. Rigg, of the University of Washington, found that the pine, and in some cases the spruce, had developed roots similar to those shown in the illustration. In some instances these were quite large and in at least one case the root formation approximated the size and shape of a 2 by 12-in. timber. These root shapes are found only in swampy areas where there is opportunity for the root to be stressed in bending, due to the possibilities of movement of the entire root mass during heavy winds. It is a fact well known to botanists that movement or stressing of a growing member accelerates growth.

Over one hundred years ago it was found that, by anchoring a tree so that it could move in only one plane, the growth at the end of one year in the plane of motion was 13/11 times the growth at right angles to that plane. The plant, therefore, seems to be able through some protective mechanism to build up strength at the point where it is most needed. In all the girder-like roots the longest axis is vertical, or in the plane of bending.

Some of the sections are very eccentric. Although in the illustration shown the center of growth approximates the center of the section, in some of the root sections which Professor Rigg has collected the center of growth is near one extremity. In such cases nearly all the growth has occurred on one side, indicating that bending has taken place in one direction only.

This concentration of wood fiber at the place most needed for strength is encountered in various types of trees in connection

Transverse Section of Root of White Pine Showing I-Beam Form

with the limb structure. An outstanding example of limbs supported by brackets at the point where they join the tree is in a redwood tree near the railway station in Palo Alto, Calif. In the State of Washington, cedar trees have also been observed to provide additional growth beneath the branches at their junction with the trunk, such growth having the general appearance of a bracket or gusset.

It may be of further interest to note that the tree roots in the bogs in this vicinity are considerably interlaced, and that at the junctions where the roots come in contact with each other they have grown together. This is probably the result of the motion previously referred to, which, by rubbing the roots against each other, produced abrasions and permitted them to grow together.

From information furnished by R. G. Tyler, M. Am. Soc. C.E., Dean of the College of Engineering, University of Washington.

Edison Exhibit at Engineering Societies Library

Early writings of Thomas A. Edison are on exhibition at the Engineering Societies Library, New York. The existence of many of the exhibits, prophetic of the inventor's future triumphs, was unknown even to Mrs. Edison, who recently inspected the display. The following information concerning the exhibit has been furnished by Harrison W. Craver, Director of the library.

One of Mr. Edison's first phonograph records, a rectangular piece of tinfoil in use in 1878, is displayed. A manuscript written by the inventor in longhand on rough tablet paper contains instructions for the operation of an incandescent lighting system. It is stated that this was "written at the Incandescent Lighting Station of the Edison Illuminating Company of Sunbury, Pa., about midnight, July 8, 1883, by Thomas A. Edison, then electrical engineer of the Thomas A. Edison Construction Company, for those who were to assume the management and operation of small three-wire stations. Of these, Sunbury was first, having been started by Mr. Edison in person, July 4, 1883."

In a copy of *Scribner's Monthly* for February 1880, Mr. Edison has endorsed an article by Francis Upton, as the "first correct and authoritative account of my invention of the electric light."

"Dangers of Electric Lighting," an article by Mr. Edison, appeared in the *North American Review* of December 1889. There are other articles by Mr. Edison on such subjects as "The Future of the Phonograph;" press notices relating to the Edison loud speaking telephone; copies of speeches delivered by the inventor; and sketches of his life and works by various authors. Besides numerous pictures showing the inventor at different stages of his career, there is one depicting him in conversation with the late Charles P. Steinmetz, famous General Electric scientist, at Briarcliff Manor on September 2, 1909.

A book containing reproductions of pages from *The Herald*, the small newspaper which Mr. Edison printed on trains while traveling as a railway newsboy, states that "he recalls in particular the sensation caused by the great Battle of Shiloh, or Pittsburg Landing, in April 1862, in which both Grant and Sherman were engaged, in which Johnston died,

and in which there was a ghastly total of 25,000 killed and wounded."

Reprints of the *New York Herald* of December 21 and 25, 1879, comment on the ultimate perfection of the electric light in tests conducted in Mr. Edison's laboratory. "The story told in our columns today," the newspaper states, "will reassure the public, whose faith in the Wizard of Menlo Park had grown feeble."

Other items include "A Complete Manual of the Edison Phonograph," with an introduction by the inventor, which was published by the U.S. Phonograph Company of Newark, N.J., in 1897; and patent applications, together with grants of patent rights.

Arbitration in Construction Contracts

AN ADDRESS entitled "Arbitration," by Charles B. Breed, M. Am. Soc. C.E., delivered a few years ago before the Boston Society of Civil Engineers, has so much value to engineers engaged upon, or interested in, arbitration of contracts that it has been reprinted from the April 1929 issue of the *Journal of the Boston Society of Civil Engineers*. A limited number of the reprints are available upon request to Professor Breed at the Massachusetts Institute of Technology.

The wording of the model law drafted by the American Arbitration Association and endorsed by the Society, constitutes an appendix to the reprint. Engineers who have been appointed arbitrators in disputed contracts—especially those who have not served in such a capacity before—will find much of value in this 60-page pamphlet.

Evils of Free Engineering Service

IN THE December issue of the *American Business World* appears a short article concerning the recent protest of the American Institute of Consulting Engineers against the practice of engineering by corporations which offer free consulting service to prospective purchasers of their products. This invasion of the field of the professional engineer does not have the approval of unbiased and fair-thinking industrial leaders.

As stated in the following quotation from the report of the American Institute of Consulting Engineers' committee on professional practices and ethics, it is evident that this practice should not be encouraged:

> It is clearly evident that such offering is made for the single purpose of selling their particular articles of manufacture, thus restricting the purchaser to products which may or may not be standard and of the best quality. It is equally evident that such practice is not only vicious from the standpoint of the engineer engaged in private practice, but deprives the purchaser of the judgment of an impartial expert whose only interest is the interest of his client.

The article concludes by strongly supporting the stand taken by the institute, in the following words:

> It is obvious then that a most destructive situation to industrial enterprise is in the process of creation. Jumping at the apparent advantages of the free consulting service, many purchasers are only serving to hasten their own ruin by availing themselves of a service tainted by selfish motives. It is neither fair to the public nor to the industry that impartial service is not the keynote of such operations.

American Society for Testing Materials Issues Index

THE AMERICAN Society for Testing Materials has released the 1931 index to its *Standards and Tentative Standards*. This will be of value to those who wish to locate specifications or methods of test in the bound publications of that society. From it can also be learned whether or not any standards on a specific subject have been issued. Copies of the index will be furnished without charge to those sending a request to the headquarters of the American Society for Testing Materials, 1315 Spruce Street, Philadelphia.

NEWS OF ENGINEERS

From Correspondence and Society Files

Y. P. SUN has been appointed Mill Manager of the Fou Foong Flour Mill Company in Shanghai. Formerly Mr. Sun was connected with the Chung Foo Union Bank of Peiping, China.

HARRY V. CAMPBELL, Railway Construction Expert for the Manila Railroad Company, Philippine Islands, was prior to this Resident Engineer and Superintendent of Construction for the same company.

J. J. KELKER, who was previously employed as Civil Engineer for the Ohio Oil Company in Marshall, Ill., is now connected with the Mid-Kansas Oil and Gas Company in Shreveport, La.

CLARENCE E. BOESCH, Senior Engineer at the U.S. Engineer Office in Memphis, Tenn., was formerly Southern Representative of the Morse Boulger Destructor Company, in Durham, N.C.

WENDELL DAWSON is Field Engineer for the Zellerbach Paper Company and the Cameron-Chandler newspaper interests of San Francisco and Los Angeles.

WILLIAM C. GIFFELLS, who in the past has been Assistant Civil and Hydraulic Engineer for the Allied Engineers, Inc., in Jackson, Mich., is now associated with the Ohio Edison Company in Akron.

MERTON R. SUMNER, until recently a sales engineer in Pittsburgh, has accepted a position with the Rockbestos Products Corporation in Chicago, Ill.

A. A. COTHER is in Tomsk, Siberia, where he is Technical Director of the Mining Equipment and Building Department of Shaftstroy. Formerly Mr. Cother was a consulting engineer in Chicago.

S. J. CHAMBERLIN, instructor in engineering drawing, Burlington Junior College, Burlington, Iowa, was formerly graduate assistant in the civil engineering department of Iowa State College, at Ames.

H. P. RUST, Manager, Inspection and Field Service, for the Baldwin-Southwark Corporation, in Philadelphia, was previously Vice-President of Harper and Taylor, Inc., in the same city.

H. W. MCCURDY has been promoted from Vice-President and General Manager, to President of the Puget Sound Bridge and Dredging Company in Seattle.

LAMBERT A. HOLLOWAY is now employed in the Sales Department of the Koppers Seaboard By-Product Coke Company in Kearny, N.J.

FRANK F. HEALEY has opened an engineering and appraisal office in Chicago. He was formerly Manager of the Engineering Department of the State Bank of Chicago.

MORRIS T. WHITMORE, heretofore General Superintendent of Robert S. DeGolyer and Company in Chicago, has opened an office for the practice of architecture and engineering in the same city.

R. R. BARRETT, formerly President of the Elizabeth Paving Company, has organized Barrett and Company, Inc., in Elizabeth, N.J., of which he is President.

J. R. KELSEY, who has been a resident of Portland, Me., has moved to San Francisco where he is employed on the San Francisco-Oakland Bay Bridge.

A. H. AYERS, until recently superintendent for Charles and George K. Thompson in Los Angeles, is now Chief Engineer for the Six Companies, Inc., in Boulder City, Nev.

NORMAN F. WILLIAMS, now affiliated with the Tennessee Electric Power Company in Chattanooga, was previously associated with W. S. Latimore of that city.

JAMES M. BROCKWAY, a former assistant hydraulic engineer, Division of Water Resources in Sacramento, Calif., is now with the International Water Commission in San Benito, Tex.

HORACE P. WARREN is now Assistant Engineer at the U.S. Engineer Office in Rock Island, Ill.

A. C. DENNIS, whose residence has been in Las Vegas, Nev., has accepted a position with the Metropolitan Water District, in Los Angeles.

EDGAR A. VAN DEUSEN has opened a consulting office at 489 Fifth Avenue, New York City, where he will specialize in a library research service for engineers and architects. For the past twenty years he has been with various public utility corporations—more recently the Central Hudson Gas and Electric Company.

Sidney Lee Davis, formerly Office Engineer for the South Porto Rico Sugar Company, at San Pedro de Macoris, Dominican Republic, is now in Benoit, Miss., where he is a civil engineer and planter.

Louis W. Turoff has been promoted from Assistant, to Associate, Highway Engineer, U.S. Bureau of Public Roads, Juneau, Alaska.

C. E. Myers announces the opening of an office in the Lincoln-Liberty Building in Philadelphia for the practice of consulting engineering.

John S. Hazelton, now affiliated with Winston Brothers Company in St. Louis, was previously Bridge Inspector for the Bridge Department of the Missouri Pacific Railroad.

Raymond G. Purnell, formerly an engineer with the Northern Illinois Agrolith Company in Chicago, is now an engineer for the Rock Road Construction Company of the same city.

Erle L. Collins, President and General Manager of the Collins Construction Company, Inc., has, since last January, also held the position of Chief Engineer of Welsh Brothers Contracting Company, Inc., Long Island City, N.Y.

Charles H. Pierce, recently with the firm of Charles T. Main, Inc., in Boston, is now a senior hydraulic engineer in the Water Resources Branch of the U.S. Geological Survey, Washington, D.C.

M. S. Bitner, a former Technical Service Engineer for the Universal Atlas Cement Company in Joliet, Ill., has a position with the E. J. Albrecht Company, in Chicago.

Changes in Membership Grades

Additions, Transfers, Reinstatements, Deaths, and Resignations

From December 10, 1931, to January 8, 1932

Additions to Membership

Allery, Marcel Paul (Jun. '31), Draftsman, Phoenix Bridge Co. (Res., 215 Main St.), Phoenixville, Pa.

Atlas, Jacob Henry (Jun. '31), Estimator, Quantity Survey Bureau (Res., 2505 Rosedale Ave.), Houston, Tex.

Baehr, Jerome Claudius (Jun. '31), Engr., Geo. J. Glover Co., Inc. (Res., 908 Webster St.), New Orleans, La.

Baker, Russell Curtis (Jun. '31), Junior Engr., U.S. Engrs., (Res. 1222 Grove St.), Vicksburg, Miss.

Bank, William George (M. '31), Asst. Div. Engr., Div. of Water (Res., 263 Vassar Ave.), Newark, N.J.

Barbehenn, Ralph Lowell (Assoc. M. '31), Structural Engr., Arthur G. McKee & Co. (Res., 1878 Lampson Rd.), Cleveland, Ohio.

Bareuther, Charles Adam (Assoc. M. '31), Prof., Applied Physics, Drexel Inst. (Res., 5533 Greenway Ave.), Philadelphia, Pa.

Baum, Albert Herman, Jr. (M. '31), Archt. and Engr. (Hoener, Baum & Froese), 3605 Laclede Ave., St. Louis, Mo.

Bedell, Victor Jarvis (M. '31), Valuation Engr., New Orleans Public Belt R.R. (Res., 1736 Pine St.), New Orleans, La.

Billingsley, Frederic Nichols (M. '31), Cons. Engr., Billingsley Eng. Co., 702 Interstate Bank Bldg., New Orleans, La.

Brown, Victor Jacob (Assoc. M. '31), Mgr., Book Dept. and Associate Editor, Gillette Pub. Co., Chicago (Res., 118 West Blair St., West Chicago), Ill.

Burgard, John Williams (Jun. '31), 507 Belgravia Court, Louisville, Ky.

Buys, Cornelius Kouwenhoven (Jun. '31), 425 West End Ave., Apartment 2-N, New York, N.Y.

Byrnes, Garrett Joseph (Jun. '31), 554 West 181st St., New York, N.Y.

Camp, Fred Albert (Jun. '31), 2211 Clement St., San Francisco, Calif.

Campbell, Duncan McEvoy (Assoc. M. '31), Asst. County Highway Engr., Cook County (Res., 7763 South Shore Drive), Chicago, Ill.

Casapulla, Thomas Joseph (Jun. '31), 1016 East 22d St., Paterson, N.J.

Coltharp, John Robert (Jun. '31), Chf. Engr., Southwestern Aerial Surveys, Inc., 108 East 10th St. (Res., 109 East 31st St.), Austin, Tex.

Cranfield, Reginald Everard (Assoc. M. '31), care, Shell Oil Co., 11th and Redondo Boulevard, Long Beach, Calif.

Davis, Edward McCollough (Assoc. M. '31), 1718 North State St., Jackson, Miss.

DeGarmo, Elmer Coleman (Assoc. M. '31), Maintenance Engr., 4th Div. South, State Road Dept., Box 1706, West Palm Beach, Fla.

Dill, Andrew Hemphill, Jr. (Jun. '31), 170 North Wycombe Ave., Lansdowne, Pa.

Diven, Alexander Samuel, 3d (Assoc. M. '31), Bldg. Mgr., Eng. Societies Bldg., United Eng. Trustees, Inc., 29 West 39th St. (Res., 528 Riverside Drive), New York, N.Y.

Dolson, Frank Edwin Jr. (Jun. '31), 6144 Waterman Ave., St. Louis, Mo.

Fenelon, Earl Stanley (Assoc. M. '31), Asst. in Chg. of Eng., H. J. Heinz Co. (Res., 1434 Davis Ave., N.S.), Pittsburgh, Pa.

Fremouw, Gerrit Dangremond (Jun. '31), with Glenn D. Holmes (Res., 155 Fernwood Ave.), Syracuse, N.Y.

Grogan, John Patrick (Jun. '31), Junior Highway Engr., State Div. of Highways, 3755a Dunnica Ave., St. Louis, Mo.

Hammel, Edward Frederic (M. '31), Engr. in Chg. of Constr., V. Green Co., Inc., 45 West 34th St., New York (Res., 254 Nuber Ave., Mount Vernon), N.Y.

Harris, Adolph Mosby (Jun. '31), 2113 Stuart Ave., Richmond, Va.

Harrje, Henry John (Jun. '31), 20 Dunlop Ave., Buffalo, N.Y.

Hawkins, Clarence Mortimer (Jun. '31), 34 Church St., Martinsville, Va.

Hay, Henry Malcolm (Jun. '31), Surveyman, U.S. Engr. Office, Pittsburgh, Pa.

Holmes, Willard Lewis (Assoc. M. '31), Draftsman, U.S. Engr. Office (Res., 1212 East 95th St.), Seattle, Wash.

Howard, Walter Joseph (Assoc. M. '31), Executive Secretary and Engr., Pacific Northwest Brick & Tile Assoc., 5308 East 43d St., Seattle, Wash.

Jacobs, Samuel Theodore (Jun. Nov. '31), 5516 Spruce St., Philadelphia, Pa.

Janssen, Theodore Armin (Jun. '31), 2146 Florida Ave., N.W., Washington, D.C.

Jones, Donald Herbert (Jun. '31), Designer, New York and Queens Elec. Light & Power Co., 147–12 State St., Flushing, N.Y.

Ketchum, Milo Smith, Jr. (Jun. '31), 1114 West California Ave., Urbana, Ill.

LaGrone, Henry Frank (Jun. '31), Hoopa, Calif.

Larkin, Thomas Bernard (M. '31), Maj., C.E., U.S.A. Dist. Engr., U.S. Engr. Office, P.O. Bldg., Vicksburg, Miss.

Lerchen, Frank Hugh, Jr. (Jun. '31), Madden Dam, Canal Zone.

Lindholm, Jalmer John (Jun. '31), R.F.D. 2, Dorset, Ohio.

Lisovitch, Vladimir Vasilovich (Jun. '31), 624 North 4th St., Philadelphia, Pa.

McKinstry, Edward Newell (Jun. '31), Box 356, Grants Pass, Ore.

McMillen, Dale Steiner (Jun. '31), Box 138, Yakima, Wash.

McNamara, Charles Clark (Jun. '31), 630 East 16th Ave., Denver, Colo.

Maguire, Michael (Assoc. M. '31), Asst. Engr., Patrick McGovern, Inc., 50 East 42d St., New York (Res., 72–16 Hayes Ave., Jackson Heights), N.Y.

Manasseh, Nicolas Elia (Jun. '31), Surv., Univ. of Michigan Archaeological Expedition, care, American Consul, Bagdad, Iraq.

Martin, William Noble (Jun. '31), Deck Officer, U.S. Coast and Geodetic Survey, Washington, D.C.

Menuez, Edward Arthur (Jun. '31), 104 Longvue Terrace, Tuckahoe, N.Y.

Mieck, Frederick Emil (Assoc. M. '31), care, Link Belt Co., Pacific Div., 400 Paul Ave., San Francisco, Calif.

Miller, Lawrence Charles (Assoc. M. '31), 316 Hales Bldg., Oklahoma City, Okla.

Motta, Arnaldo Alves da (Assoc. M. '31), Civ. Engr., P.O. Box 1759, Sao Paulo, Brazil.

Parker, Frank Woodburn (Jun. '31), care, State Highway Dept., Sandy, Ore.

Peterson, Carl Harold (Jun. '31), 7935 Parnell Ave., Chicago, Ill.

Philpott, Buel Francis (Jun. '31), Leneve, Ore.

Pirok, John Nicholas (Jun. '31), 308 North Romine, Urbana, Ill.

Powell, Carl Alden (Assoc. M. '31), Junior Civ. Engr., Eng. Dept., City of Los Angeles, 1080 Lanark St., Los Angeles, Calif.

Poze, Samuel (Jun. '31), 80 Huntington Park, Rochester, N.Y.

Prater, Herbert E. (Jun. '31), 1821 Clay St., St. Joseph, Mo.

Rankin, Ardery Robert (Jun. '31), care, Div. of Management, Bureau of Public Roads, Washington, D.C.

Ridge, Sylvester Edwin (Jun. '31), Feasterville, Pa.

Rockey, John Wesley (Jun. '31), 917 West Butler St., Philadelphia, Pa.

Schott, Eugene Albert (Jun. '31), 1011 North Walnut St., Dover, Ohio.

Solonewitz, Stanley (Jun. '31), Transitman, Topographic Div., Bureau of Highways, Borough of Brooklyn (Res., 685 Georgia Ave.), Brooklyn, N.Y.

Spirz, William (Jun. '31), 56 Langton St., San Francisco, Calif.

Stromberg, Edgar Abraham (Jun. '31), 830 North Webster Ave., Scranton, Pa.

Sturmer, Dale Emanuel (Jun. '31), Deck Officer, U.S. Coast & Geodetic Survey, *S.S. Oceanographer*, Norfolk, Va.

Veech, John Alexander (Jun. '31), care, L. & N.R.R. Engrs., Box 45, McKinnon, Tenn.

Walker, Otis Harold (Jun. '31), 715 Main, Osawatomie, Kans.

Weitzel, Harold Regis (Jun. '31), 1712 Montpelier Ave., Pittsburgh, Pa.

WENTZEL, EDWARD GEORGE (Assoc. M. '31), Constr. Engr., Crew Levick Co., 400 North Broad St. (Res., 642 West Cumberland St.), Philadelphia, Pa.

WERTSCH, ROBERT STREICH (Jun. '31), 128 High St., Oshkosh, Wis.

WESTON, STANDISH (Jun. '31), Lieut., C.E., U.S.A., Finance Officer, Publicity Officer, The Engr. School, Fort Humphreys, Va.

WHITLOCK, HAROLD JOHN (Assoc. M. '31), Associate Designing Engr., Bridge Dept., Div. of Highways, State Dept. of Public Works (Res., 2240 Markham Way), Sacramento, Calif.

MEMBERSHIP TRANSFERS

BRIGGS, ANDREW GORDON (Assoc. M. '20; M. '31), Asst. Dist. Engr., State Highway Dept., 712 Coppin Bldg., Covington, Ky.

DAVIS, WILLIAM RUSSELL (Assoc. M. '00; M. '31), Cons. Engr., 1 Columbia Pl., Albany, N.Y.

DEETS, EDWARD HENDERSON (Assoc. M. '18; M. '31), Civ. Engr., Box 2, Clarksburg, Md.

EGAN, GEORGE RAE (Jun. '27; Assoc. M. '31), State Highway Bridge Engr., State Highway Dept., Carson City, Nev.

GILES, RANALD VICTOR (Jun. '26; Assoc. M. '31), Asst. Engr., Malcolm Pirnie, 25 West 43d St., New York, N.Y.

HAKIN, WALTER ALWYNE (Jun. '26; Assoc. M. '31), Chf. Engr., Michigan Steel Casting Co. (Res., 2602 Cadillac Boulevard), Detroit, Mich.

HARMAN, HOWARD WYNES (Jun. '26; Assoc. M. '31), with Jacob A. Harman, Inc., 904 Jefferson Bldg., Peoria, Ill.

HAUG, RAGNAR (Jun. '27; Assoc. M. '31), Nygaten 39, Stavanger, Norway.

MICHAEL, WILLIAM WHIPPLE (Assoc. M. '16; M. '31), Associate Prof., Civ. Eng., California Inst. of Technology, Pasadena, Calif.

MURDOUGH, JAMES HAROLD (Assoc. M. '26; M. '31), Prof. and Head of Dept. of Civ. Eng., Texas Technological Coll. (Res., 2317 Eighteenth St.), Lubbock, Tex.

RAPP, HENRY CLINTON (Jun. '28; Assoc. M. '31), Cuidado del Consulado de E.U. de A, Valparaiso, Chile.

VANDERVOORT, BENJAMIN FRANKLIN (Jun. '09; Assoc. M. '13; M. '31), Capt., Q.M.C., U.S.A., Munitions Bldg., Washington, D.C. (Res., 8711 Green Ave., Silver Spring, Md.)

WARNOCK, JACOB EUGENE (Jun. '28; Assoc. M. '31), care, U.S. Bureau of Reclamation, 440 Custom House, Denver, Colo.

REINSTATEMENTS

WALLBILLICH, STEPHEN JOSEPH, Jun., reinstated Jan. 7, '32.

RESIGNATIONS

ALTMAN, FRANK STORK, Assoc. M., resigned Dec. 28, '31.

BEERS, HAROLD WILLIAM, Assoc. M., resigned Jan. 6, '32.

BIGELOW, HENRY WAITE, JR., Jun., resigned Dec. 28, '31.

BOYNTON, HERBERT LESLIE, Assoc. M., resigned Dec. 31, '31.

BYRNE, JEREMIAH WALTER, Assoc. M., resigned Dec. 31, '31.

CHAPPELL, CLAUDE EDWARD, Assoc. M., resigned Jan. 6, '32.

COBB, NORMAN FREMONT, Assoc. M., resigned Dec. 31, '31.

COCHRAN, HERBERT RAY, Assoc. M., resigned Dec. 16, '31.

COLLINSON, GEORGE RUDD, M., resigned Dec. 31, '31.

CONNELLY, JOHN LEO, Assoc. M., resigned Dec. 31, '31.

CONWAY, JOHN SEBASTIAN, M., resigned Dec. 31, '31.

CORNELL, MILTON LONGACRE, M., resigned Dec. 9, '31.

COTTON, CECIL RANDOLPH, Jun., resigned Dec. 31, '31.

CROCKARD, FRANK HEARNE, M., resigned Dec. 31, '31.

CULLEN, ROBERT EMMET, Assoc. M., resigned Dec. 22, '31.

DOPMEYER, ARTHUR LEOPOLD, Assoc. M., resigned Dec. 28, '31.

DREW, CHARLES DAVIS, M., resigned Dec. 23, '31.

ECKLES, ROBERT ARTHUR, Assoc. M., resigned Dec. 31, '31.

ELY, CARL BRANDES, Assoc. M., resigned Dec. 31, '31.

FARRIN, JAMES MOORE, M., resigned Dec. 31, '31.

FIELDS, FRANK VAN DUZER, Assoc. M., resigned Dec. 22, '31.

FOSTER, SAMUEL DAVIS, M., resigned Dec. 31, '31.

FRIED, FREDERICK STANLEY, Jun., resigned Dec. 17, '31.

GAUMER, ALBERT WESLEY, M., resigned Dec. 22, '31.

GOLDENBERG, MAURICE, Assoc. M., resigned Dec. 22, '31.

GOODWIN, IRVING DEAN, Assoc. M., resigned Dec. 31, '31.

GOULD, WILLIAM, Jun., resigned Dec. 31, '31.

GUTHRIE, KEITH OSMOND, Assoc. M., resigned Dec. 31, '31.

HALL, QUINCY ALLEN, Assoc. M., resigned Dec. 31, '31.

HARRIS, ALEXANDER MASON, Assoc. M., resigned Dec. 31, '31.

HEWETT, FREEMAN REGINALD, Assoc. M., resigned Dec. 11, '31.

HOWE, DONALD WALLIS, Jun., resigned Dec. 22, '31.

HOWES, FRANKLIN JOHNSON, Assoc. M., resigned Dec. 31, '31.

HYMAN, ARTHUR DAVID, Assoc. M., resigned Dec. 31, '31.

JERRARD, LEIGH PATTERSON, Assoc. M., resigned Dec. 31, '31.

JORDAHL, ANDERS, Assoc. M., resigned Dec. 22, '31.

JOSEPSBERG, BENJAMIN RUBIN, Jun., resigned Dec. 11, '31.

KLAPP, EUGENE, M., resigned Dec. 23, '31.

KNUDZON, ALF, Assoc. M., resigned Dec. 31, '31.

LAMBERT, HENRI LOUIS, Assoc. M., resigned Dec. 15, '31.

LONG, HARRY DREISBACH, Assoc. M., resigned Dec. 31, '31.

LUDLOW, JUSTIN WYMAN, M., resigned Jan. 6, '32.

MACKENZIE, DOUGLAS CARLYLE, Assoc. M., resigned Dec. 28, '31.

MCINTOSH, HAROLD AUSTIN, Assoc. M., resigned Dec. 28, '31.

MCKIM, JAMES ARTHUR, M., resigned Dec. 30, '31.

MCNEAR, GEORGE PLUMMER, JR., Assoc. M., resigned Dec. 31, '31.

MAKAROFF, GEORGE ALEXANDER, Jun., resigned Jan. 7, '32.

MALCOLM, CHARLES WESLEY, Assoc. M., resigned Dec. 31, '31.

MAYER, LEWIS CHRISTIAN, M., resigned Dec. 31, '31.

MEGRAW, WILLIAM ADAMS, M., resigned Dec. 30, '31.

MINER, ERWIN JOHN, Assoc. M., resigned Dec. 9, '31.

MOORE, LACY, M., resigned Dec. 31, '31.

NEALE, JOHN COLWELL, M., resigned Dec. 23, '31.

NEILSON, WILLIAM HARDCASTLE, M., resigned Dec. 29, '31.

NEWTON, RALPH EELLS, M., resigned Jan. 7, '32.

PARK, RICHARD, M., resigned Dec. 31, '31.

PARRISH, WILLIAM COLLIER, Jun., resigned Jan. 6, '32.

PEEK, JESSE HOPE, Assoc. M., resigned Dec. 31, '31.

PENICK, JUNIUS MARSHALL, M., resigned Dec. 31, '31.

PIKE, WALDO FRANCIS, Assoc. M., resigned Dec. 31, '31.

POPE, FRANCIS AMORY, M., resigned Dec. 22, '31.

PROVINE, LORING HARVEY, M., resigned Dec. 31, '31.

REANEY, CHARLES FRANKLIN, Assoc. M., resigned Dec. 28, '31.

RIVERS, WILLIAM FLOURNOY, Jun., resigned Dec. 31, '31.

ROCKWOOD, EDWARD FARNUM, M., resigned Dec. 28, '31.

ROSENBERGER, RAYMOND JOYCE, Assoc. M., resigned Dec. 31, '31.

SCOTT, SILAS STEELE, Jun., resigned Dec. 9, '31.

SNELL, THOMAS CULLEN BRYANT, M., resigned Dec. 22, '31.

SONDERMAN, GERHARD, Jun., resigned Dec. 22, '31.

SPESSARD, RICHARD HUYETTE, Jun., resigned Dec. 31, '31.

STOCKS, ALBERT JOHN, Jun., resigned Dec. 31, '31.

TARBOX, GEORGE EDWARD, JR., Jun., resigned Dec. 28, '31.

TAYLOR, CALEB MARSHALL, Affiliate, resigned Dec. 22, '31.

TILLOTSON, ELBERT SAUNDERS, Assoc. M., resigned Dec. 31, '31.

TUFEL, JOHN HENRY, M., resigned Dec. 31, '31.

WADDINGTON, THOMAS WASHINGTON, M., resigned Dec. 31, '31.

WALTON, HARRY COLLINS, Assoc. M., resigned Dec. 22, '31.

WELLS, REGINALD WENTWORTH, M., resigned Dec. 31, '31.

WHEELER, MILLARD FRANKLIN, Jun., resigned Dec. 31, '31.

WILHELM, GEORGE. Assoc. M., resigned Dec. 31, '31.

WINDETT, VICTOR, M., resigned Dec. 31, '31.

WOLF, LOUIS, Assoc. M., resigned Dec. 31, '31.

YAEGER, ERWIN ALBERT, Jun., resigned Jan. 7, '32.

YATES, CHARLES COLT, M., resigned Dec. 31, '31.

DEATHS

ACKERMAN, ERNEST ROBINSON. Elected Affiliate May 1, 1900; died Oct. 18, 1931.

ADDIS, WILLIAM GEORGE. Elected M., Sept. 2, 1914; died Dec. 17, 1931.

BISBEE, FRED MILTON. Elected M., May 3, 1899; died May 4, 1931.

ELLIS, GEORGE EZRA. Elected Jun., Mar. 2, 1897, Assoc. M., Mar. 7, 1900, M., Dec. 4, 1901; died Dec. 17, 1931.

FOSTER, FRANK. Elected M., June 30, 1911; date of death unknown.

KEARNY, CLINTON HALL. Elected M., Aug. 31, 1915; died Oct. 22, 1931.

MEIGS, MONTGOMERY. Elected M., Mar. 5, 1879; died Dec. 9, 1931.

MERICKEL, BERNARD J. Elected Jun., Oct. 1, 1926; died Dec. 21, 1931.

MILLER, JOHN HARRY. Elected Jun., Dec. 5, 1927; died Oct. 14, 1931.

MIRICK, ALFRED STOWE. Elected Assoc. M., Oct. 5, 1909; died Dec. 5, 1931.

PEW, ARTHUR. Elected M., Dec. 2, 1885; died Dec. 26, 1931.

POSKE, HARRY CHRISTIAN. Elected Assoc. M., Jan. 15, 1917; died Oct. 11, 1931.

SCHUYLER, PHILIP. Elected Affiliate Dec. 15, 1924, M., Oct. 1, 1926; died Dec. 11, '31.

WILLIAMS, GARDNER STEWART. Elected Assoc. M., Oct. 2, 1895, M., Dec. 6, 1899; died Dec. 12, 1931.

TOTAL MEMBERSHIP AS OF JANUARY 8, 1932

Members	5,876
Associate Members	6,336
Corporate Members	12,212
Honorary Members	18
Juniors	2,840
Affiliates	124
Fellows	5
Total	15,199

Men and Positions Available

These items are from information furnished by the Engineering Societies Employment Service with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices and the fee is to be found on page 97 of the 1931 Year Book of the Society. Unless otherwise noted, replies should be addressed to the key number, Engineering Societies Employment Service, 31 West 39th Street, New York, N.Y.

Men Available

Executive Engineer; M. Am. Soc. C.E.; 37; university graduate; 15 years experience on large developments, chiefly hydro-electric; estimates, organizing, planning, and general management construction—foreign and domestic. Location immaterial, but interested in foreign work requiring careful planning for speed and cost; also, preliminary investigations, designs, and reports. Available immediately. C-9694.

Civil Engineer; Jun. Am. Soc. C.E.; 26; married; graduate, 1929; 3 years experience before graduation in irrigation and drainage; 2 years experience since graduation in investigation and design of hydro-electric developments. Desires either office or field work. Location immaterial. References furnished. D-200.

Civil Engineer; 38; single; university graduate, B.S. in C.E., and foreign graduate mining engineer; draftsman-designer, checker, estimator; steel and reinforced concrete construction; past 3 years, design and drafting constructions used in oil refineries; also, several years design and drafting of sewers and water works. Willing to go anywhere, here or abroad. D-83.

Civil Industrial Engineer; Assoc. M. Am. Soc. C.E.; university education; 25 years experience on Government, municipal, public service, and industrial projects; last 12 years partly devoted to industrial management problems, effecting economies and reorganization. Record covers investigations, reports, designs, estimates, contracts, and supervision. Invites contact with engineers or managers planning to develop broader fields. C-5717.

Civil Engineer; Assoc. M. Am. Soc. C.E.; 19 years experience—past 3 years as estimator. Has designed reinforced concrete and structural steel, and has had charge of office, surveying, and railroad work. Knows all the principal New York City subcontractors. A-2505.

Civil Engineer; M. Am. Soc. C.E.; 14 years experience; desires responsible position, preferably on highway or railroad construction or location; has had considerable experience in general and triangulation surveys. Speaks and writes Spanish and French. Location immaterial. B-9765.

Civil Engineer; Assoc. M. Am. Soc. C.E; 32; graduate of university in Northwestern Europe; 5 years experience in New York City as designer and checker of structural steel, reinforced concrete, and timber construction for industrial buildings; 1 year field experience; desires permanent position as chief draftsman or squad leader. B-7845.

Graduate Civil Engineer; Assoc. M. Am. Soc. C.E; varied, comprehensive experience in irrigation, reclamation, highway, and farm survey work; 6 years responsible charge of, and detail work in, industrial plant building layout, design, construction, layout, and installation of machinery, transmission, conveying, and power plant equipment. Desires responsible position utilizing experience referred to. C-6910.

Civil Engineer; experienced in city planning and highway location and construction; has specialized in surveys, including triangular and topography, by plane table. Studies, estimates, and reports, in the United States and foreign countries. Accustomed to handling men and familiar with conditions in Latin America. B-7788.

Construction Engineer; Assoc. M. Am. Soc. C.E.; 37; C.E. graduate, Michigan State; 4 years production and plant engineering; 11 years heavy construction—hydro-electric, industrial, and New York subways. Has completed as resident engineer hydro development, dam, penstock, power house, and transmission line. Desires position with good company. B-4052.

Civil Engineer; Jun. Am. Soc. C.E.; 27; single; college graduate, 1926. Has had experience in surveying, valuation, highway construction; 2 years in South America in charge of construction of oil storage tank farm and general terminal construction. Location immaterial. C-2971.

Junior Civil Engineer; 24; 5 years construction experience as inspector, timekeeper, field estimator, and surveyor on bridge, railroad, and building construction; capable office man; 5 years clerical experience. Now in junior year at night engineering school. Wishes position anywhere within commuting distance of New York City. D-151.

Graduate Civil Engineer; Jun. Am. Soc. C.E.; 26; married; 2 years experience in structural drafting with large company; 3 months city surveying; desires position in any field of engineering within limits of training or experience with corporation, contractor, consultant, or architect—field or office work. Location Pennsylvania or neighboring states. D-176.

Civil Engineer; Assoc. M. Am. Soc. C.E.; Pennsylvania registration; 14 years experience in building construction, commercial and industrial types—both concrete and steel. Cost work, field superintendence, and office engineering, including design, for general contractors, for industrial engineers, for hospital, and for subway. C-5695.

Recent Graduate; Jun. Am. Soc. C.E.; 24; single; Master's degree in structural engineering; 5 summers experience in surveying and drafting in Western Canada, including railroad and highway construction; 2 years experience as graduate assistant in first-class engineering school. Structural work preferred, but not essential. Available immediately. Location immaterial. D-218-3114-A-4 San Francisco.

Graduate Civil Engineer; Jun. Am. Soc. C.E.; 26; married; 2 years experience as structural detailer and three years as structural designer. Middle West location preferred but not necessary. Desires position as engineering instructor or designer. D-219.

Engineer; Jun. Am. Soc. C.E.; 28; married; licensed highway engineer in New Jersey; 5 years experience in highway, water supply, and construction work; desires position with municipality or contractor anywhere in the United States. Available January 1. C-3439.

Civil Engineer; Jun. Am. Soc. C.E.; 23; single; graduate, University of Michigan, 1929; good scholastic record; two years experience in construction work; 8 months graduate study in sanitary engineering. Available in February. Location immaterial. C-7632.

Graduate Civil and Hydraulic Engineer; Jun. Am. Soc. C.E.; married. Experienced in hydro-electric plant testing and operation; current meter work; general municipal engineering, including construction, supervision of sewerage, and highway systems. Qualified to teach or do hydraulic research. B.S. and M.S. degrees from ranking engineering institutions. Location immaterial. C-4487.

Civil Engineer-Instructor; Assoc. M. Am. Soc. C.E.; 30; married; M. Sc. in C.E.; 12 hours education courses; 6 years on staff of large university teaching civil engineering, in charge of courses in surveying; several years experience on municipal improvement and design, as resident engineer and superintendent of construction. Available June 15, 1932. D-232-3112-A-5 San Francisco.

Civil Engineer; Jun. Am. Soc. C.E.; 25; single; 1928 graduate; 1½ years experience as superintendent of building construction; 9 months as inspector on railroad electrification; 1 year as structural draftsman on subway and vehicle tunnel design. Desires opportunity as field engineer or structural designer. Available immediately. C-3252.

Civil Engineer; Jun. Am. Soc. C.E.; 26; single; graduate, Penn State College—C.E., 1930. Desires work on construction, structural steel, or concrete designing. Will consider any kind of work. Speaks Polish, Lithuanian, and Slavic. D-234.

Structural Engineer Sales Executive; M. Am. Soc. C.E.; experienced in designing structural steel and ornamental iron for both riveted and welded construction; experienced in estimating costs, burden application, and sales. Available April 1. B-7445.

Construction Engineer; Assoc. M. Am. Soc. C.E.; New York State license; 20 years experience on surveys, and construction of dams, aqueducts, subways, foundations, and underpinning; estimating and bidding; instructor of materials. Thorough, practical, and of highest integrity. Best references. Desires position with contractor, engineering firm, or university. D-205.

Civil Engineer and Surveyor; Assoc. M. Am. Soc. C.E.; 43; licensed engineer and surveyor in New York and New Jersey. Over 20 years practical experience in building construction, railroad construction, and municipal engineering; sanitary engineering and surveying. Desires connection with sanitary engineer or municipality. Available immediately. References. A-915.

Lehigh Graduate; Jun. Am. Soc. C.E.; 25; single; C.E. degree. Testing laboratory and surveying experience; 2½ years experience on structural steel detailing, erection diagrams, bridges, and office buildings; considerable mill building work. Would like work in a designing or drafting office. D-225.

Civil Engineer; Jun. Am. Soc. C.E.; 27; single; Tau Beta Pi; 5 months experience on railroad survey; 8 months plant and material inspection in field, Highway Commission; 3 years and 3 months bridge design, Highway Commission; steel inspection in shops; student airplane pilot. Prefers work involving considerable traveling, foreign or home. D-244.

Municipal and Sanitary Engineer; M. Am. Soc. C.E.; married; graduate civil engineer; 15 years experience on design and supervision of construction dams, water works, sewage disposal plants, paving, storm drainage, sewerage and water systems, plumbing installations, inspections, reports, and appraisals. At present chief engineer, secretary and treasurer of consulting engineering firm. Location immaterial, if position is permanent. D-251.

Civil Engineer; Jun. Am. Soc. C.E.; 26; married; graduate in civil engineering, Georgia School of Technology; 4 years experience in the design of state highways and structures. Desires permanent position as designer or draftsman with construction company or consulting engineer. Available short notice. C-8821.

Sanitary and Hydraulic Engineer; Assoc. M. Am. Soc. C.E.; 31; married; civil engineering graduate; 10 years experience on water supply, sewage, and water power developments, including surveys, studies, reports, designs, specifications, and construction. Interested in sanitation, water supply, or hydraulic work. Capable of taking charge of project. Also interested in college teaching. D-186.

Graduate Civil Engineer; Assoc. M. Am. Soc. C.E.; 8 years experience in design and construction, including estimates, inspection, and surveys, on railroads, subways, buildings, bridges, and general construction work. Capacity to assume responsibility. Desires connection with construction company, consultant, contractor, or architect—preferably field engineering-construction or related work, also sales-engineering or instructorship. C-2605.

Construction Superintendent and Engineer; Assoc. M. Am. Soc. C.E.; 20 years experience on school and monumental buildings, heavy concrete construction, bridges, and foundation work. Has recently specialized in foundation and bridge work, including foundations for large buildings and bridge piers. Thoroughly under-

stands supervision heavy equipment, pile driving, cofferdam, concrete work, and general construction. D-261.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; graduate, Rensselaer Polytechnic Institute; experience with a civil and sanitary engineer doing office and field work, including work on field party, inspecting, drafting, and computing; recent experience in stadia surveying, computing, and plotting. C-9813.

INSTRUCTOR; Jun. Am. Soc. C.E.; 27; Master's degree in civil engineering, 1928; 3 years experience as draftsman and designer with large steel corporation; 2 years experience research and tests of sand, cement, concrete, and steel. Practical experience in inspection and tests of concrete. Able to instruct in structural design, laboratory, or surveying. D-207.

CIVIL AND INDUSTRIAL ENGINEER; M. Am. Soc. C.E.; graduate; licensed; design and construction of hydro-electric developments, industrial plants, and housing groups for both Government and private interests; 20 years experience covering supervision of entire projects from inception to completion, including preliminary investigations, designs, estimates, and construction work. B-2835.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 26; single; graduate, Massachusetts Institute of Technology. Extensive knowledge of construction materials. Wide experience with construction projects. Desires connection with consulting engineer, contractor, or company associated with construction material. Available at once. D-246.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 22; single; graduate, Drexel Institute; 2½ months oil refinery testing; 5 months jig and die construction; 2½ months building construction clerk; 5½ months Congressional stream survey report; 3 months mechanical analysis of stresses. Desires report, research, or testing work. D-264.

JUNIOR CONSTRUCTION ENGINEER AND DRAFTSMAN; Jun. Am. Soc. C.E.; 22; single; graduate, Yale University, 1930; 14 months drafting, designing, and construction experience in pulp and paper mill. Desires opportunity in any phase of construction. Available immediately. Location anywhere. D-258.

STRUCTURAL ENGINEER; Jun. Am. Soc. C.E.; 23; graduate, Drexel Institute Cooperative Engineering School, 1931. Desires position with architect. List of practical experiences with ratings obtained sent on request. D-269.

RECENT BOOKS

New books of interest to Civil Engineers, recently donated by the publishers to the Engineering Societies Library, will be found listed here. A comprehensive statement regarding the service which the Library makes available to members is to be found on pages 87 to 89 of the Year Book for 1931. The statements made regarding the books are taken from the books themselves and this Society is not responsible for them.

A.S.T.M. TENTATIVE STANDARDS 1931. Philadelphia, American Society for Testing Materials, 1931. 1008 pp., illus., diagrs., charts, tables, 9 × 6 in., cloth, $8; paper, $7.

This book contains the tentative specifications, methods of test, and recommended practices which had been proposed to the association but not formally adopted in September 1931. Although they are not official, they represent the latest thought of the committees and are widely used. There are given 180 standards, of which 42 appear for the first time. Among the latter are standards for structural steel for ships, helical springs, steel forgings for locomotives, steel pipe, alloy castings, wall board, concrete aggregates, soluble nitrocellulose coatings, insulating materials, and rubber hose.

BOGENBRÜCKEN (HANDBUCH FÜR EISENBETONBAU). By J. Melan and T. Gesteschi. 4 ed. Bd. 11, Lief. 1–6. Berlin, W. Ernst & Sohn, 1931. Illus., diagrs., charts, tables, 11 × 8 in., paper 40 r.m; bound in linen, 43 r.m.

This volume of the new edition of the *Handbuch für Eisenbetonbau* brings together, in revised form, everything relating to the design of reinforced-concrete arch bridges. The first section discusses the theory, static calculation, and tests of arches, types, structural elements, erection, repair, and reconstruction. A large number of noteworthy bridges are described. The work is provided with a bibliography, profusely illustrated with drawings and photographs, and affords a comprehensive survey of modern theory and practice.

COLLOID CHEMISTRY, Vol. 3. Collected and edited by J. Alexander. New York, Chemical Catalogue Co., 1931. 655 pp., illus., diagrs., charts, tables, 9 × 6 in., cloth, $10.50.

This collection of papers by an international group of authorities is devoted to technological applications of colloid chemistry. Eleven papers treat of general principles and six of mechanical matters of interest to many industries, such as cohesion and adhesion, the wetting of solids by liquids, catalysis, crushing and grinding, filtration, and flotation. Twenty-five other papers deal with colloids in glass and porcelain, cements and mortars, the colloid chemistry of petroleum and iron, and similar topics. The whole forms a valuable, suggestive survey of modern information.

COVERED BRIDGES IN AMERICA. By R. Wells. New York, William E. Rudge, 1931. 135 pp., illus., 10 × 8 in., cloth, $7.50.

The author of this volume has industriously collected information upon the existing covered bridges of the country and presents an account of them, going into detail on the subject of those of unusual interest. Excellent photographs of one hundred and thirty-five bridges admirably illustrate the story and add greatly to the value of the book as a record of early bridge building.

DEEP BOREHOLE SURVEYS AND PROBLEMS. By M. H. Haddock. New York, McGraw-Hill Book Co., 1931. 296 pp., illus., diagrs., charts, tables, 9 × 6 in., cloth, $4.

A comprehensive survey of all of the important and accepted means of surveying the courses of deep boreholes and orienting their cores. The evolution of modern devices for surveying boreholes is traced very fully. Problems in prospecting and location work, provided by study of the data afforded by borehole surveys and cores, are discussed. A bibliography is included.

DIE GEOLOGISCHEN GRUNDLAGEN DER VERBAUUNG DER GESCHIEBEHERDE IN GEWÄSSERN. By J. Stiny. Vienna, J. Springer, 1931. 120 pp., illus., diagrs., charts, 10 × 6 in., paper, 13 r.m.

The geological principles underlying erosion by torrential rivers are clearly and concisely set forth for the benefit of engineers and foresters. The various ways in which erosion occurs are described, and appropriate methods for combating them are discussed. A bibliography is given.

INTERNATIONALE SPRACHNORMUNG IN DER TECHNIK, BESONDERS IN DER ELEKTROTECHNIK. By E. Wüster. Berlin, VDI-Verlag, 1931. 431 pp., charts, tables, 10 × 7 in., cloth, 20 r.m.

A great deal has been done in different countries to standardize the terminology of engineering, but little consideration has been given to means of international intercourse. The present book discusses this subject in detail. The author first investigates the structure and development of engineering terms in the principal languages. The methods which have been used to standardize these terms internationally are discussed, and the limitations of each pointed out. The conclusion is reached that an artificial international language is the best means, and the advantages of Esperanto are set forth. The book affords much information upon the definitions and terms adopted by engineering standards associations all over the world.

REINFORCED CONCRETE RESERVOIRS AND TANKS. By W. S. Gray. London, Concrete Publications, Ltd., 1931. 212 pp., illus., diagrs., charts, tables, 9 × 6 in., cloth, 10 s.

A manual on the design and construction of plain and reinforced concrete reservoirs, tanks, swimming pools, and other water-containing structures both above and below ground level. Methods of design are discussed in detail and very practically. Complete designs are given for a variety of structures, with details of joints, reinforcements, and forms. Photographs of construction methods are included.

REPORT OF STRUCTURAL STEEL WELDING COMMITTEE OF THE AMERICAN BUREAU OF WELDING. New York, American Welding Society, 1931. 208 pp., illus., diagrs., charts, tables, paper, $1.

This volume represents the conclusion of the committee that a comprehensive series of tests on the subject of "obtaining reliable information upon which to base safe unit working stresses in the designing of welded structures," should be made before final recommendations are promulgated. The subject matter is divided into ten sections, and cross reference is facilitated by the Dewey decimal index system.

STORY OF THE ROAD. By J. W. Gregory. New York, Macmillan Co., 1931. 311 pp., illus., maps, tables, 9 × 6 in., cloth, $4.

Professor Gregory first discusses the origin of roads, prehistoric trade routes, and the ancient roads of Great Britain, Rome, China, and Peru. Coming to more recent times, he writes on the evolution of modern roads, the development of modern methods of construction, the problems of road construction, and the road systems of the principal countries. Without attempting a detailed history of the subject, he has produced an interesting and informative account of road development.

THE ROEBLINGS, A CENTURY OF ENGINEERS, BRIDGE-BUILDERS, AND INDUSTRIALISTS. By H. Schuyler. Princeton, N.J., Princeton University Press, 1931. 425 pp., illus., 10 × 8 in., cloth, $5.

The history of this great family of engineers and bridge builders, from the birth of John A. Roebling to the present time, is here presented in readable, interesting fashion. The story practically begins ninety years ago, when the first crude ropewalk was constructed on Roebling's farm in Saxonburg, near Pittsburgh, and the manufacture of wire rope begun. Succeeding steps, the construction of the first suspension bridges, the removal to Trenton, and the future development of the business are presented. The careers of John A. Roebling's sons, especially Washington A. Roebling, are sketched in full. As the book is primarily for the general reader, the lives and personalities of the men are emphasized rather than the technical details of their bridges, but there is much to interest the engineer.

TRANSACTIONS OF THE AMERICAN GEOPHYSICAL UNION TWELFTH ANNUAL MEETING, April 30 and May 1, 1931, Washington, D.C., Nat. Research Council, 1931. 229 pp., figs., diagrs., charts.

This interesting and comprehensive volume covers an account of the general assembly. Also, there are sections on geodesy, seismology, meteorology, terrestrial magnetism and electricity, oceanography, volcanology, and hydrology. The papers and abstracts of papers by various authors have, in most instances, been previously indexed from various sources.

TRANSPORTING THE A.E.F. IN WESTERN EUROPE, 1917–1919. By William J. Wilgus. New York, Columbia University Press, 1931. 612 pp., illus., diagr., charts, tables, maps, cloth, $12.50.

A full account of the railroad and water transportation of the American Expeditionary Force in France, written from a point of view that will render the book valuable to the layman as well as to the engineer. Roads, inland waterways, railway operation, erection and repair facilities, traffic control, terminals, sidings, and multiple tracking are among the many subjects and aspects of the situation discussed in this important book.

CURRENT PERIODICAL LITERATURE

Abstracts of Articles on Civil Engineering Subjects from Magazines in This Country and in Foreign Lands

Selected items from the current Civil Engineering Group of the Engineering Index Service, 29 West 39th Street, New York, N.Y. Every article indexed is on file in The Engineering Societies Library, one of the leading technical libraries of the world. Some 2,000 technical publications from 40 countries in 20 languages are received by the library and are read, abstracted, and indexed by trained engineers. With the information given in the items which follow, you may obtain the article from your own files, from your local library, or direct from the publisher. Photoprints will be supplied by this library at the cost of reproduction, 25 cents per page, or technical translations of the complete text may be obtained when necessary at cost.

BRIDGES

ABUTMENTS. Simplified Bridge Abutment Contains Small Quantity of Concrete, R. C. Hardman. *Eng. News-Rec.*, vol. 107, no. 22, Nov. 26, 1931, p. 857, 2 figs. Features of skeleton abutment developed for use in the Republic of Panama; abutment is rigid two-column bent with tie members extending to footings.

BRIDGE DESIGN. Application of Equivalent Loading Curve for Bridges, G. H. Hargreaves. *Concrete and Constructional Eng.*, vol. 26, no. 12, Dec. 1931, pp. 661–669, 9 figs. Application of method recently issued by British Ministry of Transport to: slab bridges, longitudinal beam and slab bridges, transverse spans, continuous spans, arches, and frames, box culverts, retaining walls, and truss and suspension bridges.

BRIDGE FOUNDATIONS. Design of Bridge Substructures, H. C. Adams. *Surveyor*, vol. 80, no. 2078, Nov. 20, 1931, pp. 493–497, 1 fig. Bearing value of foundation bed; abutments; cantilever abutment walls; vertical beam type of abutment; abutments for arch bridges; abutment wing walls; abutment with tied-back wings; skeleton or open abutments; piers; piles; excavation, backfill, and drainage. Before Instn. Mun. and County Engrs.

CONCRETE ARCH, OREGON. Designing First Freyssinet Arch to Be Built in United States, C. B. McCullough and A. L. Gemeny. *Eng. News-Rec.*, vol. 107, no. 22, Nov. 26, 1931, pp. 841–845, 5 figs. Design of highway bridge, at mouth of Rogue River in Oregon, consists of seven 230-ft. open-spandrel-type arches; adoption of Freyssinet system of arch decentering by use of crown jacks and subsequent stress adjustment; rib stress by Freyssinet adjustment compared with fixed-arch methods; jack installation at crown.

CONSTRUCTION, OHIO. Ohio Rushes Bridge Building to Relieve Unemployment, J. H. Burkey. *Eng. News-Rec.*, vol. 107, no. 24, Dec. 10, 1931, pp. 927–930, 1 fig. 300 bridges costing $3,500,000 contracted for winter construction with local labor, except for supervision of construction; terms of contracts; special plans for timber bridges.

HIGHWAY, DESIGN. Design of Highway Bridges. *Concrete and Constr. Eng.*, vol. 26, no. 11, Nov. 1931, pp. 626–627, 1 fig. Presentation of equivalent loading curve, accompanied by table of working stresses in concrete, recently made available by Ministry of Transport; impact is included.

ILLINOIS. High-Level Bridge Eliminates Old Swing Span, C. H. Sandberg. *Eng. News-Rec.*, vol. 107, no. 21, Nov. 19, 1931, pp. 796–798, 4 figs. Design and construction of new steel-truss, double-track bridge having a total length of 1,606 ft., including one 440-ft. skewed through-truss channel span; bridge crosses the Illinois River near Chillicothe, Ill.

RAILROAD. Swing Draw Span During Erection, F. J. Bishop. *Ry. Age*, vol. 91, no. 19, Nov. 7, 1931, pp. 705–706 and 708, 6 figs. Outline of unusual methods employed in renewing superstructure of Lower Maumee River Bridge at Toledo, Ohio.

STEEL ARCH. New Type of Arch Bridge Built at Unusually Low Cost. *Contract Rec.*, vol. 45, no. 49, Dec. 9, 1931, pp. 1462–1467, 13 figs. Design and construction of steel arch, 7-span, 1,200-ft., highway bridge at Paris, Ont.; use of 36-in. rolled beams for arch ribs; fabrication and erection; cost reduced to $6 per sq. ft. of floor; rib anchorages are of special design; skewed piers imposed.

STEEL TRUSS. Lake Champlain Bridge, C. M. Spofford. Am. Soc. Civil Engrs.—PROCEEDINGS, vol. 57, no. 10, Dec. 1931, pp. 1467–1499, 15 figs. Planning, design, and construction of bridge from Crown Point, N.Y., to Chimney Point, Vt.; traffic counts, estimates, finances, and proposed toll rates; comparison of various types of bridges studied for this crossing; bridge of continuous steel truss type, is 2,187 ft. long, with maximum span 434 ft. long and clearance of 90 ft.

STEEL TRUSS, CONSTRUCTION. Cantilever Erection of Truss Bridge, H. E. Crider and H. G. Neyenesch. *Eng. News-Rec.*, vol. 100, no. 21, Nov. 19, 1931, pp. 799–802, 5 figs. Methods used in the erection of a 440-ft. through-truss channel span and two-span continuous trusses of the Sante Fe River Bridge crossing the Illinois River at Chillicothe, Ill.; part of the top chord of the old swing span removed to clear the bottom of new fixed span; channel span was cantilevered 176 ft. from steel bent on piling to temporary bent on pier of old bridge.

SUSPENSION, CABLES. Stringing Rope-Strand Cables Features St. Johns Bridge Construction, R. Boblow. *Eng. News-Rec.*, vol. 107, no. 20, Nov. 12, 1931, pp. 779–782, 5 figs. Cables for 1,207-ft. span at Portland, Ore., erected in 23 days without footwalks; advantages of stranded design; erection system of endless hauling ropes; foundation and approach construction; concreting operations for viaduct piers; twisting of strand around hauling rope corrected by the use of special swivel; stiffening-truss erection.

WOODEN. Galloway Rapids Bridge, Prince Rupert, S. N. Williscroft. *Can. Engr.*, vol. 61, no. 20, Nov. 17, 1931, pp. 9–10, 4 figs. Construction of a bridge consisting of creosoted-timber trestle approaches at either end with 200-ft. creosoted through Howe-truss center span set on concrete piers; truss was floated into position on scows; example of laminated chord adopted by Department of Public Works.

BUILDINGS

BRICK. Marvelous Brick Walls from Days of Genghis Khan, A. A. Zakharoff. *Bldg. Economy*, vol. 7, no. 12, Dec. 1931, pp. 6–20, 21 figs. Examples of great and remarkable twelfth and fourteenth-century buildings and monuments constructed in Turkestan of local brick.

CHICAGO. Chicago Post Office, A. Shaw and M. Gunderson. *West Soc. Engrs.—Journal*, vol. 36, no. 5, Oct. 1931, pp. 257–263, 3 figs. Preliminary description of general architectural and engineering features of the world's greatest postal service building which is now under construction in Chicago; limited clearances in many places dictated extensive use of silicon steel; an interesting side-light on the project is the fact that nearly 125 tons of air per minute will be used for ventilation and smoke removal.

COSTS. Building Materials and Construction Costs—VI, T. F. Laist. *Gen. Bldg. Contractor*, vol. 2, no. 12, Dec. 1931, pp. 20–23. Plain and reinforced concrete work; operations and costs; approximate costs placing concrete; prices and weights of concrete aggregates; crushed slag as coarse aggregate; reinforcing steel, weights, and labor cost; membranous waterproofing.

STADIUMS, COVERED. Outstanding Construction Accomplishment—Erection of Large Sports Arena in Five Months. *Contract Rec.*, vol. 45, no. 45, Nov. 11, 1931, pp. 1343–1359, 11 figs. Symposium on construction of Maple Leaf Gardens, Toronto, seating 13,000 people, intended for indoor sport exhibitions; details of concrete and steel framework, domed roof, and ice surface; heating, ventilating, ice making, and sound systems.

WIND BRACING. Measurement of Wind Stresses, F. H. Frankland. *Can. Engr.*, vol. 61, no. 21, Nov. 24, 1931, p. 23. Instruments installed in Empire State Building to secure data on stiffening of structures; results of observations. Before annual convention of Am. Inst. Steel Construction.

CITY AND REGIONAL PLANNING

SMALL CITIES. City Planning as Related to the Smaller Cities, E. A. Wood. Am. Soc. Civil Engrs.—TRANSACTIONS, vol. 95, 1931, pp. 1075–1079 and (discussion) 1080–1088. Indexed in Engineering Index 1929, p. 403, from PROCEEDINGS, Aug. 1929.

ZONING. Preparation of Zoning Ordinances. *U.S. Bur. Standards—Bldg. and Housing Pub.*, no. BH 16, July 1, 1931, 28 pp. Guide for use of those who draft zoning ordinances; designed to aid in arrangement of provisions to promote uniformity in form and arrangement, and to point way to economy of time in drafting and use of such ordinances; history of zoning.

CONCRETE

CONSTRUCTION. Monolithic Concrete Construction, J. F. Hough. *Constructor*, vol. 13, no. 11, Nov. 1931, pp. 21–22, 5 figs. Practical suggestions on preparation and use of wood forms. (To be continued.)

MIXING. Admixtures and Workability of Concrete, G. M. Williams. *Am. Concrete Inst.—Journal*, vol. 3, no. 3, Nov. 1931, pp. 199–208. Discussion of paper previously indexed from issue of Feb. 1931; author's closure.

Coordinated Laws of Concrete Mixtures and Their Application, J. A. Kitts. *Concrete*, vol. 39, no. 6, Dec. 1931, pp. 13–15 and 18. Basic principles of concrete-making; procedure for calculating mixtures and yield; grading of mixed aggregate. (Continuation of serial.)

NEW YORK. "The Borough Plan" with Special Reference to Parks and Boulevards, C. U. Powell. *Mun. Engrs. Journal*, vol. 17, 3d quarterly issue, 1931, pp. 76–99 and (discussion) 99–103, 11 figs. Planning of the Borough of Queens, which has a population of over a million inhabitants, an assessed valuation of approximately two billion dollars, and an area five times as great as that of the Borough of Manhattan.

RESERVOIRS. Reinforced Concrete Reservoirs and Tanks, W. S. Gray. London, Concrete Publications, Ltd., 1931, 212 pp., illus., diagrs., charts, tables. 10s. Manual on design and construction of plain and reinforced-concrete reservoirs, tanks, swimming pools, and other water-containing structures, both above and below ground level; complete designs are given for variety of structures, with details of joints, reinforcement, and forms. Eng. Soc. Lib., N.Y.

WATERPROOFING. Tests of Integral and Surface Waterproofings for Concrete, C. H. Jumper. *Am. Concrete Inst.—Journal*, vol. 3, no. 4, Dec. 1931, pp. 209–242, 9 figs. Results of tests by U.S. Bureau of Standards; some 90 commercial waterproofing materials were tested; also, high calcium lime, dolomitic lime, and potter's flint; permeability of concrete; composition and method of application of integral and surface waterproofing materials; absorption tests; paints and varnishes.

CONSTRUCTION INDUSTRY

ACCIDENT PREVENTION. Safe Construction of Ohio Building. *Constructor*, vol. 13, no. 11, Nov. 1931, pp. 35–37, 3 figs. Accident prevention methods used in building of new $5,000,000 Ohio State Office Building, in Columbus, Ohio.

COSTS. Unit Bid Summary. *West Construction News*, vol. 6, no. 21, Nov. 10, 1931, pp. 598, 600, 602, 604, and 630. Unit prices bid and descriptions of: street and road work, bridge construction, water works, and reclamation work in California and other Western states.

Unit Bid Summary. *West Construction News*, vol. 6, no. 23, Dec. 10, 1931, pp. 656, 632, 634, and 636. Unit costs bid on street and road work in California, Nevada, Utah, and other Western states.

RUSSIA. Construction in Soviet Russia, L. G. Khvostovsky. *Constructor*, vol. 13, no. 12, Dec. 1931, pp. 16–18 and 38, 3 figs. Possibilities for American contractors to sell their services in U.S.S.R.; little road building; development of inland waterways.

VARIATION. Causes of Seasonal Fluctuations in Construction Industry. *Monthly Labor Rev.*, vol. 33, no. 3, Sept. 1931, pp. 6–33. Summary of information obtained in survey by Bureau of Labor Statistics; views presented are those of leading firms of architects, large building contractors, small home builders, and owners of

"7630 pounds per square

THE PROOF OF THE PAVEMENT. Drilling concrete test cores. On the left are two cores already drilled; on the right the 6-inch steel bit is cutting another. The 'Incor' cores cut from the Old Spanish Trail at 28 months developed an average ultimate strength of 7630 pounds per square inch.

HOW 'INCOR' CEMENT DIFFERS (Left) The diagram illustrates the difference in chemical constitution between ordinary Portland Cement and 'Incor' Portland Cement. The complete circles symbolize molecules of *tri*-calcium silicate which are active. The incomplete circles symbolize molecules of *di*-calcium silicate which are sluggish. This difference in refinement, which insures extremely high *early*-and *ultimate* strength, is achieved by double burning, an exclusive 'Incor' feature.

buildings on question of winter operations in construction industry.

DAMS

Concrete Arch. Seattle Completes Diablo Dam, R. G. Skerrett. *Universal Engr.*, vol. 54, no. 4, Oct. 1931, pp. 15–20, 13 figs. Previously indexed from *Compressed Air Mag.*, May 1931.

Concrete Gravity. First Stage of Calgary's New Water Works, J. G. Bennett. *Contract Rec.*, vol. 45, no. 49, Dec. 9, 1931, pp. 1149–1452 and 1467, 7 figs. Construction methods employed on Glenmore concrete gravity dam, 122 ft. high, 1,050 ft. long, carrying concrete arch highway bridge on its top; construction plant; grouting.

Concrete Lining. Experiments in Gunite Control at Syracuse Reservoir, E. P. Stewart. *Eng. News-Rec.*, vol. 107, no. 21, Nov. 19, 1931, pp. 807–810, 5 figs. New data on gunite control secured in constructing lining for Westcott Reservoir at Syracuse, N.Y.; field and laboratory tests disclose important relations of nozzle velocity, water content, and sand gradation to strength and absorption; devising nozzle-velocity meter.

Design. Talsperren (Sammlung Goeschen 1044), N. Kelen. Berlin and Leipzig, W. de Gruyter & Co., 1931, 144 pp., illus., diagrs., charts, tables, 1.80 rm. Simple condensed exposition of principles of dam design and construction. Eng. Soc. Lib., N.Y.

Earthquake Resistance. Water Pressures on Dams During Earthquakes, H. M. Westergaard. Am. Soc. Civil Engrs.—Proceedings, vol. 57, no. 9, Nov. 1931, pp. 1303–1318, 3 figs. Theoretical mathematical study in connection with design of Hoover Dam; formulas for change of water pressure during earthquake for straight dam with vertical upstream face; pressures are same as if certain body of water were forced to move back and forth with dam while remainder of reservoir is left inactive.

High Dams. Past Experience with High Dams and Outlook for Future, A. J. Wiley. Am. Soc. Civil Engrs.—Transactions, vol. 95, 1931, pp. 130–138. Indexed in Engineering Index 1929, p. 549, from Proceedings, Nov. 1929.

Hoover Dam Project. First Six Months' Progress at Hoover Dam. *Eng. News-Rec.*, vol. 107, no. 24, Dec. 10, 1931, pp. 923–926, 6 figs. Construction progress report; Boulder City housing and feeding facilities completed; highways and railroad built to bottom of gorge; 14,000 ft. of pioneer headings driven for diversion tunnels.

Hydraulic Fill. Composition of Earth Dams—IV. *Eng. News-Rec.*, vol. 107, no. 24, Dec. 10, 1931, pp. 917–922, 6 figs. Symposium of two papers: Water Content Is Major Factor in Determining Permeability, E. M. Moore; Stability During Construction Must Be Considered, N. F. Williams; water content of earth before it is subjected to pressure is more important than size of particles in determining permeability; improvements in methods of construction.

Multiple Dome. Construction Methods and Plant Layout at Coolidge Dam, in Arizona, J. G. Tripp. Am. Soc. Civil Engrs.—Transactions vol. 95, 1931 pp. 159–168 and (discussion) 169–231, 11 figs. Indexed in Engineering Index 1929, p. 550, from Proceedings, Nov. 1929.

Reservoirs. New Distributing Reservoir in Syracuse, E. P. Stewart. *Am. Water Works Ass'n—Journal*, vol. 23, no. 12, Dec. 1931, pp. 2106–2112. Description of Westcott Reservoir having capacity of 105,000,000 gal.; gunite lining of reservoir; joints in gunite lining and placement of gunite; leakage; pipe connections.

Silt. Silting and Life of Southwestern Reservoirs, R. G. Hemphill. Am. Soc. Civil Engrs.—Transactions, vol. 95, 1931, pp. 1060–1072 and (discussion) 1073–1074, 1 fig. Records of silt load of principal streams of Southwest; weight of deposited silt; removing silt from reservoirs; prevention of silting; estimating effective life of reservoir.

FLOOD CONTROL

Levees. Device for Heightening Levees Threatened with Overtopping, J. B. Drisko. *Eng. News-Rec.*, vol. 107, no. 24, Dec. 10, 1931, p. 937, 1 fig. Method practiced on delta section of Vistula River in Danzig, consists of knockdown board cofferdam filled with earth or manure.

Mississippi River. Better Control of Lower Mississippi, J. P. Kemper. Civil Eng. (N.Y.), vol. 1, no. 15, Dec. 1931, pp. 1396 and 1404. Discussions by H. Engels and O. P. Erickson of paper previously indexed from issue of August 1931.

FOUNDATIONS

Construction. Foundation Methods—IV, W. D. Chapman. *Commonwealth Engr.*, vol. 19, no. 3, Oct. 1, 1931, pp. 85–88, 4 figs. Pile tests; extracting sheet piling; driving piles under water; total allowance for temporary compression per blow; Hiley formula for pile tests.

HYDROLOGY, METEOROLOGY, AND SEISMOGRAPHY

Drought. Drought of 1930, J. C. Hoyt. *Am. Water Works Ass'n—Journal*, vol. 23, no. 11, Nov. 1931, pp. 1822–1864, 8 figs. Statistical analysis; nature and extent of drought of 1930 as compared with past droughts, in terms of rainfall, run-off, and groundwater; effects upon water supplies including agriculture, power, navigation, city supply, waste disposal, and recreational and industrial uses; social, political, and economic elements involved.

Low Stream Flows Again Cause Concern in Southeastern States. *Eng. News-Rec.*, vol. 107, no. 21, Nov. 19, 1931, p. 817. Groundwater reserves are depleted below all previous records; lack of rainfall adds to shortage in run-off; municipal water supplies are benefiting by experience gained in 1925 drought period.

Oregon. Hydrologic Resources and Phenomena of Oregon, H. S. Rogers and F. Merryfield. *Am. Water Works Ass'n—Journal*, vol. 23, no. 12, Dec. 1931, pp. 2120–2128. Principles of hydrological phenomena; methods of preliminary project study; methods of forecasting; regulation of water resources.

Rain and Rainfall. Frequency and Intensity of Excessive Rainfalls at Boston, Massachusetts, C. W. Sherman. Am. Soc. Civil Engrs.—Transactions, vol. 95, 1931, pp 9.51–960 and (discussion) 961–968, 4 figs. Indexed in Engineering Index 1930, p. 1483, from Proceedings, Apr. 1930.

Run-Off. Run-off Investigations in Central Illinois, G. W. Pickels. *Univ. Ill.—Eng. Experiment Station—Bul.*, no. 232, vol. 29, no. 3, Sept. 8, 1931, 131 pp., 38 figs. Purpose of this investigation was to determine "n" in Kutter's formula for flow in open drainage channels in Central Illinois; maximum discharge for which drainage channels in Central Illinois should be designed; annual yields of small watersheds in Central Illinois.

INLAND WATERWAYS

Canals. Chesapeake and Delaware Canal, E. I. Brown. Am. Soc. Civil Engrs.—Transactions, vol. 95, 1931, pp. 716–763 and (discussion) 764–765, 11 figs. Indexed in Engineering Index 1930, p. 261, from Proceedings, Feb. 1930.

IRRIGATION

Reservoirs. Policies with Respect to Reservoirs, E. Mead. *New Reclamation Era*, vol. 22, no. 11, Nov. 1931, pp. 230–233, 8 figs. Commissioner of U.S. Bureau of Reclamation states that expansion of irrigated area depends on storage; financing irrigation reservoirs; water-right questions on interstate streams; examples of present activities of bureau; Hoover Dam construction shows value of water; purpose of Owyhee and Cle Elum storages. Before Ass'n West. State Engrs.

MATERIALS TESTING

Concrete. Researches on Durability of Concrete, H. F. Gonnerman. *Contract Rec.*, vol. 45, no. 46, Nov. 18, 1931, pp. 1380–1382, 1 fig. Previously indexed from various sources.

Concrete Columns. Reinforced Concrete Column Investigations. *Am. Concrete Inst.—Journal*, vol. 3, no. 3, Nov. 1931, pp. 157–175, 6 figs. Symposium of three items: Third Progress Report of Committee 105; Third Progress Report on Column Tests at Lehigh University, W. A. Slater and I. Lyse; Third Progress Report on Column Tests Made at the University of Illinois, F. E. Richart and G. C. Staehle; effect of amount and grade of spiral reinforcement on strength of columns.

Fatigue. Influence of Rapidly Alternating Loading on Concrete and Reinforced Concrete, E. Probst. *Structural Engr.*, vol. 9, no. 12, Dec. 1931, pp. 410–429 and (discussion) 430–432, 15 figs. Results of 10 years' research at Karlsruhe Institute of Technology; correlation of permanent and elastic axial strains under alternating load; stress-strain curves above endurance limit; formation of cracks; Poisson's ratio for concrete and alternation of loads; breathing of cracks.

Welds. Strength of Arc-Welded Joints, F. R. Freeman. *Instn. Civil Engrs.—Min. Proc.*, vol. 231, pt. 1, 1930–1931, pp. 283–304 and (discussion) 305–366, 32 figs. partly on supp. plate 5. Previously indexed from Excerpt *Min. Proc.*, no. 4808, 1930–1931.

PORTS AND MARITIME STRUCTURES

Piers, Construction. Construction of First Concrete Pier on Seattle Waterfront, W. F. Way. *Eng. News-Rec.*, vol. 107, no. 24, Dec. 10, 1931, pp. 914–916, 3 figs. Report on construction of new American Can Company's pier supported on concrete cylinders with diameters of 4$^{1}/_{3}$ ft.; five loads for pier and shed aggregating 1,800 lb. per sq. ft.; cylindrical steel forms, sunk by pneumatic process and filled in dry, carry 800 tons.

Thames. Tidal Thames, C. R. Sutton. *Engineer*, vol. 152, nos. 3956 and 3957, Nov. 6, 1931, pp. 494–496 and Nov. 13, pp. 520–521; see also *Engineering*, vol. 132, no. 3434, Nov. 6, 1931, pp. 587–589, 3 figs. Historical review; data on river walls, foreshores, dredging, fresh-water flow, docks, bridges, tunnels, weirs, and river-side industries; tidal data. Presidential address before Instn. Civil Engrs., Nov. 3, 1931.

Toledo, Ohio. Providing Enlarged Facilities for Coal and Ore. *Ry. Age*, vol. 91, no. 23, Dec. 5, 1931, pp. 855–859, 4 figs. Chesapeake and Ohio Railroad makes extensive waterfront development at Presque Isle, near Toledo, so as to handle important rail and water traffic more efficiently; character of shore development; dock wall construction; track layout and piers; coal pier and car dumpers; ore dock and ore machines; speed of unloading.

ROADS AND STREETS

Asphalt Construction. A Compact Hot Mix Plant. *Contractors and Engrs. Monthly*, vol. 23, no. 2, Aug. 1931, pp. 66–68, 6 figs. Plant installed for paving operation near Ingersoll turned out 1,000 lb. batches as follows: for top, 300 lb. of fines, 650 lb. of stone, and 50 lb. of asphalt; for base, 275 lb. of fines, 675 lb. of stone, and 50 lb. of asphalt; plant was run by steam engine located at asphalt kettle end of plant and operated by the same boiler which heated the kettle and asphalt cars, and ran the asphalt pump.

Bituminous Materials. Emulsifying Action of Asphalt Fillers, A. R. Ebberts. *Can. Engr.*, vol. 61, no. 23, Dec. 8, 1931, pp. 17–18, and 48, 3 figs. Previously indexed in Engineering Index, 1930, p. 1523, from issue of May 20, 1930.

Brick Pavements. 22-Mile Brick-Paved Akron-Canton Superhighway, H. G. Sours. *Roads and Streets*, vol. 71, no. 11, Nov. 1931, pp. 447–451, 8 figs. Procedure followed in construction of brick pavement on heavy concrete base 40 ft. wide; longitudinal contraction joints were spaced at 10-ft. intervals; transverse joints at 40-ft. intervals and 2-in. depth; bumpometer used in checking surface.

Design, Intersections. Intersection Design Primary Highway Problem in New Jersey, C. S. Hill. *Eng. News-Rec.*, vol. 107, no. 22, Nov. 26, 1931, pp. 834–838, 8 figs. Design of road-crossing structures; principle of flaring roadways merging into intersection; circles for distributing traffic between several intersecting roads; grade separations with connecting ramps for interchange of traffic; clover-leaf design; layout to induce proper direction of traffic.

France. French Roads During Last Century, P. LeGavrian. *Permanent Inst. Ass'n Road Congresses—Bul.*, vol. 20, no. 77, Sept.-Oct. 1931, pp. 247–265. Development of road system; use of roads; roadways; road technic; regulating traffic; road budgets.

Grading. Advance Planning for Highway Grading, R. W. Edwards, D. M. Beach, and F. C. Turner. *West Construction News*, vol. 6, no. 22, Nov. 25, 1931, pp. 606–608, 2 figs. Study of typical northern California grading project by Division of Management, U.S. Bureau of Public Roads; preparing detailed schedule of grading operations for use of prospective bidders well in advance of awarding contract; proposed highway has length of 4.1 miles, following closely line and grade of existing 9-ft. road, mostly in side-hill excavation.

Low-Cost. Engineering Procedure in Local Road Improvement, P. M. Tebbs. *Eng. News-Rec.*, vol. 107, no. 23, Dec. 3, 1931, pp. 892–894, 4 figs. Design and construction methods must correspond with low order of work; disproportionate refinement and cost constitute grave danger; method of random location of highway curves.

The Local Road Today, T. R. Agg. *Eng. News-Rec.*, vol. 107, no. 23, Dec. 5, 1931, pp. 875–876, 1 fig. General survey of physical condition and traffic service of secondary roads of United States, comprising system in excess of 2,400,000 miles, of which not more than 10 per cent has been improved with reasonable grades, drainage structures, and adequate all-weather surfaces; improvement of this system should begin at once.

Materials for Low-Cost Roads Are Widely Diversified, J. T. Pauls. *Eng. News-Rec.*, vol. 107, no. 23, Dec. 3, 1931, pp. 879–883, 10 figs. Classification by types; bituminous coarse surfaces; bituminous-treatment surfaces; non-bituminous surfaces; untreated surfaces.

Pavement, Asphalt Economic Features of Emulsified Asphalt Types, C. L. McKesson. *Roads and Streets*, vol. 71, no. 8, Aug. 1931, pp. 307–311, 11 figs. Various methods of construction described and illustrated; annual cost of standard paved surfaces and bituminous treated surfaces; economic advantages of bituminous types for light and medium traffic.

Road Construction, Finland. Building Highway to Arctic Ocean. *Roads and Streets*, vol. 71, no.12, Dec. 1931, pp. 489–490, 2 figs. Construction of road for horse and motor traffic from Kyro to Petsamo, 229 km. long, costing about $1,150,000.

Road Construction, New York. Unfavorable Materials Supply Causes Excessive Amount of Trucking. *Roads and Streets*, vol. 71, no. 12, Dec. 1931, pp. 491–493, 3 figs. Construction of seven-mile stretch between Pine Bush and Walden on New York State Highway No. 208; experience with automatic cement batchers.

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Gaisman. *Rubber Age (Lond.)*, vol. 12, no. 10, Dec. 1931, pp. 352–356 and (discussion) 356–358. Problems to be overcome; history of road construction; ideal form of road surface; modern plague of noise; vibration; advantages; finance of rubber roadways.

SAND ASPHALT. Sand-Asphalt Road Along Ocean Shore Line. *Construction Methods*, vol. 13, no. 8, Aug. 1931, pp. 36–38, 6 figs. Construction practice on road 10.7 miles long, located near Cape Hatteras in North Carolina; rough grading done by strike-off pulled by tractor along creosoted-wood side forms; sand-asphalt mixing plants set up alongside sand dunes.

SEWERAGE AND SEWAGE DISPOSAL

ALLENTOWN, PA. Allentown Sewage Treatment Works, H. Krum. *Sewage Works Journal*, vol. 3, no. 4, Oct. 1931, pp. 647–655, 3 figs. Construction and operation of plant serving city of 97,000; plant consists of rock chamber, pumping station and laboratory, two detritus tanks, screen and incinerator house, six Imhoff tanks, ejector house, chlorinating house, sludge beds, and garage; cost data.

CONSTRUCTION OF SEWERS. Sewer Construction Through Embankment and Soft Ground, W. S. Wheeler. *Pub. Works*, vol. 62, no. 12, Dec. 1931, pp. 24–25 and 69, 2 figs. Description of unusually difficult job of jacking 60-in. corrugated pipe through railroad embankment at Dover, N.H.

DESIGN OF SEWERS. Design of Combined Sewerage Systems, D. K. McKinzie. *Instn. Mun. and County Engrs.—Journal*, vol. 58, no. 11, Nov. 24, 1931, pp. 857–863 and (discussion) 864–866, 1 fig. Computation of run-off, taking into account percentage of impermeable area and entrance allowance; flow in sewer.

DISPOSAL PLANTS, OPERATION. Flow of Sewage Through Sewage Works in Relation to Settlement of Suspended Solids, W. Clifford. *Surveyor*, vol. 80, no. 2076, Nov. 6, 1931, pp. 427–428. Flow through works; dissipation of kinetic energy; rate of deposit. Before Roy. Sanitary Inst.

Sewage Works Operation and Control. Am. Soc. Civil Engrs.—TRANSACTIONS, vol. 95, 1931, pp. 1273–1293. Final report of committee of Sanitary Engineering Division; operation and control of sewage works; state supervision; financing sewage works operation; qualifications for superintendents; schools for operators; sewage works associations; operation and maintenance cost data; Ohio State Department of Health Law, and Sewer Rental Law.

FILTERS. Trickling Filter Loadings, B. F. Hatch. *Water Works and Sewerage*, vol. 78, no. 11, Nov. 1931, pp. 327–328. Present and proposed loading expressions; allowable loadings; designed loadings for trickling filters of selected Ohio sewage treatment works; trickling filter loading and performance at selected Ohio sewage works, 1927–1931. Paper before Fifth Annual Ohio Conference on Sewage Treatment.

INFILTRATION. Tests Reveal Low Infiltration Rate on New Jersey Outfall Sewer, E. T. Killam. *Eng. News-Rec.*, vol. 107, no. 24, Dec. 10, 1931, pp. 934–935. Infiltration tests on reinforced-concrete pipe sewer, built in 1929 by Second River Joint Meeting, of Essex County, N.J., with diameters varying from 24 to 60 in., showed infiltration of 20,530 ft. to be 1,610 gal. per mile per day—only 13 per cent of that allowed by specifications.

MOSCOW, RUSSIA. Experimental Plant to Determine Method of Treatment of Moscow's Sewage, S. Stroganov. *Mun. Sanitation*, vol. 2, no. 12, Dec. 1931, pp. 574–578, 2 figs. Construction of Kozhukhovo Aeration Plant designed to treat 36,900 cu. m. in 24 hr.; plan to mechanize screen cleaning; air provided by turbo-blowers; composition of sewage in Feb. 1930; Translation of article in *Kommunalnoye Khozyaystvo*.

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MOFFAT. Completion of Moffat Tunnel of Colorado, C. A. Betts. Am. Soc. Civil Engrs.—TRANSACTIONS, vol. 95, 1931, pp. 334–371 and (discussion) 372–378, 16 figs. Indexed in Engineering Index 1930, p. 1826, from PROCEEDINGS, Nov. 1930.

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SUBWAY CONSTRUCTION, NEW YORK. Fulton Street, East River Tunnels, New York, N.Y., M. I. Killmer. Am. Soc. Civil Engrs.—PROCEEDINGS, vol. 57, no. 10, Dec. 1931, pp. 1516–1544, 18 figs. Construction, by shield method of two tubes, of new subway for City of New York; details of power houses, caissons, shields, tunnel plant in rear of shield, dock plant and gantries, shaft plant, tunnel bulkheads, and safety screens; High Street Station.

WATER PIPE LINES

CORROSION. Corrosion of Water Mains, H. R. Redington, J. L. W. Birkinbine, and F. N. Speller. *Am. Water Works Ass'n—Journal*, vol. 23, no. 11, Nov. 1931, pp. 1649–1693. History of steel pipe; corrosion, theory, types, causes; U.S. Bureau of Standards soil corrosion investigation; water treatment; exterior coatings; economic importance of reduced resistance in pipes; flow factors; flow through unlined pipe; tests of lined pipe.

NEW YORK. The 20-Mile, 17-ft. Tunnel of New York City Water Supply. *Eng. and Contracting*, vol. 70, no. 12, Dec. 1931, pp. 327–330, 3 figs. Progress report; contractor's plant; construction of shafts; drilling and blasting procedure; roof support; handling water.

PIPE-LINE CORROSION. Pipe-Line Corrosion and Soil Conductivity. *Eng. News-Rec.*, vol. 107, no. 4, July 22, 1931, p. 135. Brief report on surveys of corrosion, electric current, and soil on 9 pipe lines recently carried out in Texas, Oklahoma, and Kansas, which have led the Bureau of Standards to conclude that there is a definite correlation between pipe corrosion and soil resistivity and that, where soil conductivity is high, corrosion occurs.

STEEL. Large Steel Pipe Protected by New Type of Machine-Wound Wrapping of Cement Mortar and Fabric. *Construction Methods*, vol. 13, no. 12, Dec. 1931, pp. 22–26, 12 figs. Practice followed in construction of 26 miles of steel pipe, 56 to 66 in. in diam., now being laid across San Joaquin Valley in California as one of final steps in bringing Hetch Hetchy water to San Francisco."

WATER TREATMENT

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FILTRATION MATERIALS. Filter Sand, J. W. Armstrong. *Am. Water Works Ass'n—Journal*, vol. 23, no. 11, Nov. 1931, pp. 2031–2033. Discussion, by R. Hulbert and F. W. Herring, of paper previously indexed from issue of Sept. 1931.

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MODERN METHODS. Modern Aspects of Water Purification, E. S. Chase. *Can. Engr.*, vol. 61, no. 20, Nov. 17, 1931, pp. 11–13 and 32. Previously indexed from *Water and Water Eng.* (Special Institution Number), 1931.

SIAM. Water Supply Conditions in Siam, W. Buchler. *Water Works Eng.*, vol. 84, no. 23, Nov. 18, 1931, pp. 1607–1608 and 1644, 6 figs. Description of conditions in regard to water supply in Siam; with exception of Bangkok which has modern system, primitive methods of obtaining water prevail; polluted water from canals used for drinking purposes.

TASTE AND ODOR REMOVAL. Cause and Removal of Earthy Tastes in Water, B. A. Adams. *Water and Water Eng.*, vol. 33, no. 396, Nov. 20, 1931, pp. 572–574. Review of literature on subject; earthy taste in water is due primarily to actinomyces; activated carbon is effective means of removing tastes due to actinomyces. Bibliography. Before Pub. Works, Roads, and Transport Congress.

TURBIDITY. Purify Highly Turbid Water, C. F. Linck. *Water Works Eng.*, vol. 84, no. 25, Dec. 16, 1931, pp. 1727–1728. Problem which Leavenworth, Kans., has to meet in taking its supply from Missouri River; great variation in suspended matter. Before Am. Water Works Ass'n.

WATER SOFTENING. Effect of Dissolved Manganese Salts on the Softening Power of Base-exchange Materials, B. A. Adams. *Water and Water Eng.*, vol. 33, no. 395, Oct. 20, 1931, pp. 533–535. Report on research carried out at Teddington Chemical Research Laboratories as part of the program of the Water Pollution Research Board of The Department of Scientific and Industrial Research; manganese ions are removed from solution by base-exchange materials and can be subsequently replaced by sodium ions causing reduction in softening power of base-exchange materials.

WATER WORKS ENGINEERING

FLORIDA. Water Piped from Mainland to Peninsula Through Swamp Land in New Water Supply of St. Petersburg, C. F. Ruff. *Water Works Eng.*, vol. 84, no. 21, Oct. 21, 1931, pp. 1487–1488 and 1517, 6 figs. Well field located on mainland to avoid salt contamination; laying of 26 miles of pipe line through salt marsh land, with wet sand, swamp muck, and other free-flowing substances.

GREAT BRITAIN. Llanelly Water Works Extension. *Engineer*, vol. 152, no. 3953, Oct. 16, 1931, pp. 403–404, 4 figs. Water is led from natural course of river by means of dwarf dam, 48 ft. in length, at point 1 1/2 miles upstream from Borough of Kidwelly; dam diverts water into sedimentation reservoir, with capacity of 500,000 gal.; from sedimentation reservoir water passes by gravity through pipe line to pumping station; pumping plant's total capacity is 3,000,000 gal. in 24 hours, and it comprises three units—each of 1,000,000 gal. capacity.

OPERATION. Group Operation of Water Utilities, E. B. Walthall. *West City*, vol. 7, no. 12, Dec. 1931, pp. 17–20, 1 fig. Discussion of centralized management and control practiced by California Water Service Co., which operates 28 properties acquired from 18 separate ownerships in four years; physical connections made; engineering, financial-accounting, and other departments; local plants and local office accounting; results and savings effected.

RATES. Planning the Future Financial Structure of a Water Works, W. A. Kunigk. *Am. City*, vol. 45, no. 6, Dec. 1931, pp. 68–71, 3 figs. Paper before Am. Water Works Ass'n, previously indexed from their journal, Aug. 1931.

SHREVEPORT, LA. Shreveport Completes New Water Works Improvement Program, T. L. Amiss. *Water Works Eng.*, vol. 84, no. 24, Dec. 2, 1931, pp. 1669–1670 and 1695–1696, 2 figs. Description of new Cross Lake pumping and filtration plant forming part of 12-year, two million dollar plan.

SPRINGFIELD, MASS. Cobble Mountain Power Development. *Power Plant Eng.*, vol. 35, no. 19, Oct. 1, 1931, pp. 986–987, 2 figs. Details of dam, reservoir, and hydro-electric plant of 33,000-kw. capacity; spillway and tunnel; water control valves; water wheels and generators; operation of station.

WATER WORKS, CUBA. Glimpses of Water Works in Cuba, J. F. Pierce. *Water Works Eng.*, vol. 84, no. 18, Sept. 9, 1931, pp. 1259–1260 and 1281, 4 figs. General survey of water supply situation on the island; great shortage of water curtails its use in some sections; wells; few rivers available for supply.